COMBINED EDITION
THE Petroleum Engineer

Powder River Basin — Another Great Area of Promise
Crude Oils From Powder River Basin
Control of Pipe Line Booster Stations
Veteran Field Fills Big Role

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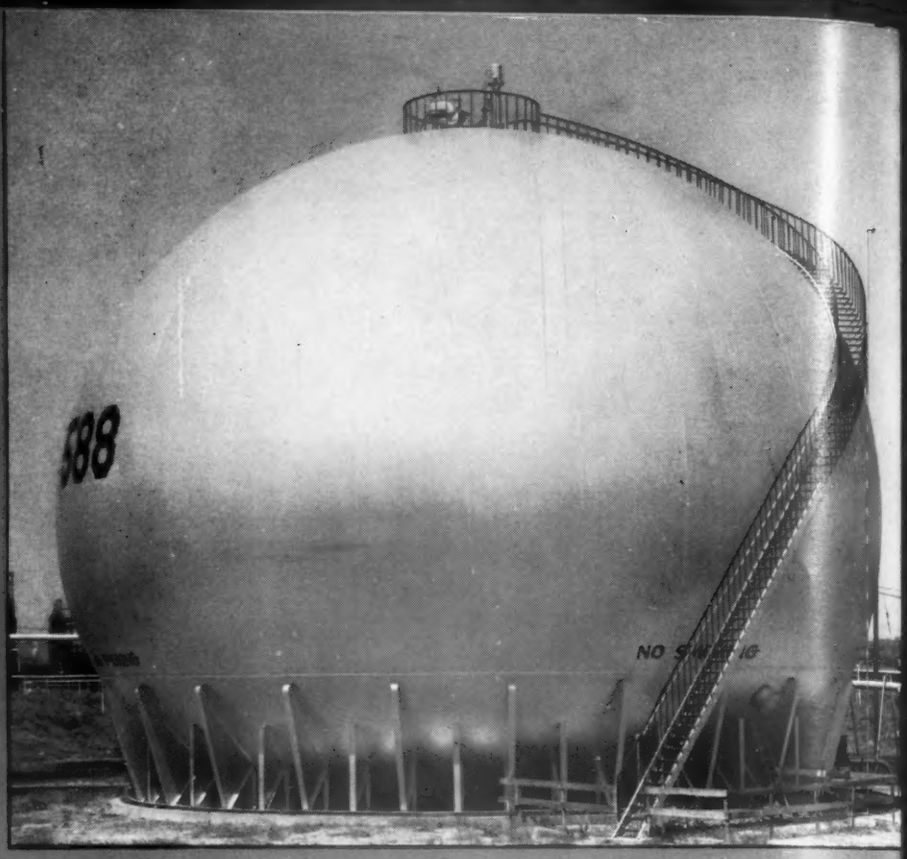
SEPTEMBER 1952

Storing Butane



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• Drilling and Producing • Refining and Gas Processing • Oil and Gas Pipelining

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Paley Report Suggests U. S. Oil Policy

THE Paley Group report, 16 months in the making, is being studied with great interest by the petroleum industry. The section on oil and gas is part of an over-all study made by the President's Materials Policy Committee, headed by William S. Paley, on the long range aspects of the nation's materials problem. Covering, as they do, requirements of the next quarter of a century, the findings are of extreme significance.

As a basis for what is to follow, the report points out the unquestioned fact that demand for oil products can be expected to increase steadily during the next 25 years. It is estimated that during this period consumption will double in the United States, triple in Europe, and quadruple elsewhere. Demand for oil by peoples of the free world was approximately 10,000,000 barrels a day in 1950; it will apprach 27,000,000 barrels a day in 1975.

This tremendous increase in demand can be met, but there should be some shift in the emphasis on where the oil is produced, according to the Paley Group. Presently, the United States with less than 30 per cent of the world's reserves is producing about half of the world's oil. Although oil is being discovered in this country more rapidly than it is being produced, the belief is expressed that somewhere along the line the continued increase in production will have to reach a peak and begin to decline. For this reason it is considered good economics for the United States to turn more and more to imports to meet the growing demand. At some point, also, it may advisable to supplement with liquid fuels derived from oil shales and produced synthetically. In the matter of oil shales, the recommendation is for the federal government to give limited aid to private concerns for construction of small-scale commercial plants for production of oil from shale, with the view of gaining technical knowledge that can be used later when utilization of shale deposits may become essential.

An "underground stockpile" of semi-proved oil deposits that could be drilled as rapidly at not too great expense in case of emergency also is suggested. This policy is advocated in lieu of wildcatting, which, during the last war, was shown to have its shortcomings. New oil, it was found then, could not be acquired as easily or as cheaply by wildcat drilling as by drilling additional wells in known fields. Off-shore lands are considered a means of providing this "underground stockpile." The recommendation is made that, regardless of whether these lands shall finally be declared state or federally owned, wide spacing of wells and limited withdrawals should be required, thus prolonging the productive life of the off-shore pools and providing proved areas of reserves that would lend themselves to rapid drilling in event of another war.

A vital part of any "reserve capacity" program, of course, would be the necessity for assuring corresponding standby refining and transportation capacity, otherwise the crude product could not be transformed into the refined product as quickly as would be required. This policy, too, is recommended.

These are some of the points discussed by the voluminous report made by the Paley Group. Generally speaking, the petroleum industry is found to occupy a favorable position. There may be some differences of opinion regarding certain of the committee's conclusions. Nevertheless, deserving consideration should be accorded the report as a whole, because quite conceivably it may provide the basis for policy discussions between government and the petroleum industry for the next 25 years.—F.H.L.

UNSURPASSED

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With the EDITORS.....

Market Capacity for Organic Chemicals

Interesting indeed are the figures shown in the fall of 1951 by P. S. Keith and J. H. Arnold, researchers, of the quantities of oxygenated chemicals producible from one or more Hydrocol units, one process for synthesizing fuels from natural gas via the Fischer-Tropsch synthesis. Their figures show — and they know probably as much about the field as any living men, much more than most men — that the production of 100,000 bbl per day of fuels (all kinds) by synthesis will yield 838,000,000 lb of ethanol — ethyl or "grain" alcohol — while the estimated production of this material from all sources in 1948 was 980,000,000 lb.

By simple arithmetic it is determined that synthesis of about 120,000 bbl per day of synthetic fuels will yield enough of this alcohol to glut the market, and eliminate from that picture all other sources of ethyl alcohol. If chemicals from these synthetic processes such as Hydrocol or Synthol are to be considered as byproducts they must take a nuisance value status and therefore could be expected to sell for prices lower than such materials from other sources could be manufactured, with disastrous results to present chemical industry.

Similarly, acetone production from the synthesis of 100,000 bbl of fuels per day — requiring 500 billion cubic feet of natural gas per year — would be 245,000,000 lb per year; synthesis of twice that much fuel, a "drop in the bucket" in our domestic fuel requirements, would make 490,000,000 lb annually, or more than our entire acetone production from all sources, which was 480,000,000 lb. in 1948. Yet again, acetic acid in the amount of 346,000,000 lb per year would be produced while synthesizing the 100,000 bbl of fuels per day; consequently, when making 120,000 bbl of fuels daily the byproduct acetic acid would equal 1948's acetic production from all other sources. By the same calculation it would require the synthesis of about 300,000 bbl per day of fuels to saturate the acetaldehyde market, our production of the latter being 440,000 lb in 1948. For some other chemicals the production is considerably smaller and would endanger the market price structure only with the production of much greater quantities of those synthetic fuels.

The point of these quantities is to indicate what may be expected, and how soon, in the event of embarkation on a huge synthetic fuels program such as is urged by certain officials in the present Federal Government. In recent Bureau of Mines estimates more than 50 per cent of the total income from the synthetic fuels projects is accredited to chemicals, a position which has led the National Petroleum Council to state that it is evident that this plant is more of a chemical venture than a synthetic liquid fuels project.

In either case, what happens when an overproduction of chemicals results? The market is glutted, the prices drop, and the byproduct chemicals from fuel synthesis, being distress products having mainly "nuisance value" — if they are still considered byproducts — can undersell the materials made from other sources, can hold what market outlet there is but at greatly reduced prices. Consequently the return from this source approaches the vanishing point, so net cost of fuels rises, while private industry is "pinched out" of its market. Even if we accept for discussion purposes the Bureau estimates of total fuel cost, much lower than those of industry, the cost reduction from chemical sales must be large to make this fuel competitive. And even the Ebasco estimate of 27.1 cents per gal for fuels must be more than half written off by chemical proceeds to be competitive. At NPC's 41 cents the situation patently becomes impossible.—A.L.F.

Texas' Gas Gathering Tax

District Judge Jack Roberts at Austin has declared the Texas gas gathering tax, enacted by the last session of the legislature, to be unconstitutional. Immediately Texas' attorney general, Price Daniel, announced that the ruling would be appealed and carried all the way to the United States Supreme Court if necessary. The decision was in the case of the Michigan-Wisconsin Pipe Line Company, but also applies to the Panhandle Eastern Pipe Line Company and the Amarillo Oil Company, Judge Roberts said.

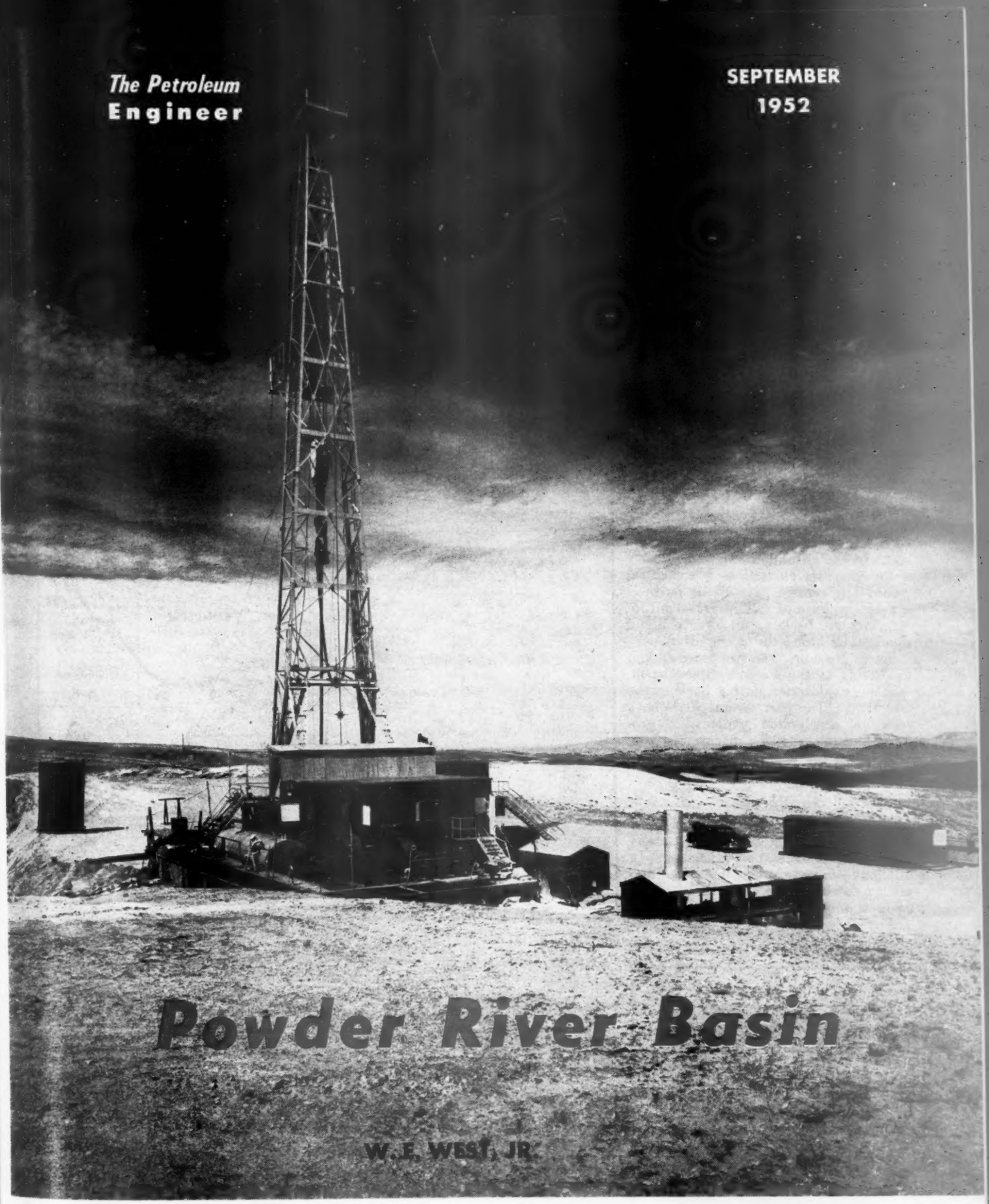
The presiding judge asserted that he considered the tax constitutional on gas gathered for intrastate commerce and on certain combinations of intrastate and interstate operations, but not on gas moving exclusively for out-of-state use. As the legislature, in writing the law, stated in effect that the constitutionality of the entire law depended on the constitutionality of each and all of its parts, Judge Roberts ruled that the entire law was invalid.

The tax is for 9/20 of 1 cent per 1000 cu ft of gas gathered from the ground, and was expected to provide the state with a revenue of $14,000,000 a year. Some pipe line companies have been paying the tax without protest, other have been fighting it in the courts. Fifty-nine suits have been filed since the law went into effect last September.

Because of the many millions of dollars involved, the results of this legal skirmish are being watched with great interest by all gas pipe line companies whose systems originate in the state of Texas.—F. H. L.

The Petroleum **Engineer**

SEPTEMBER 1952

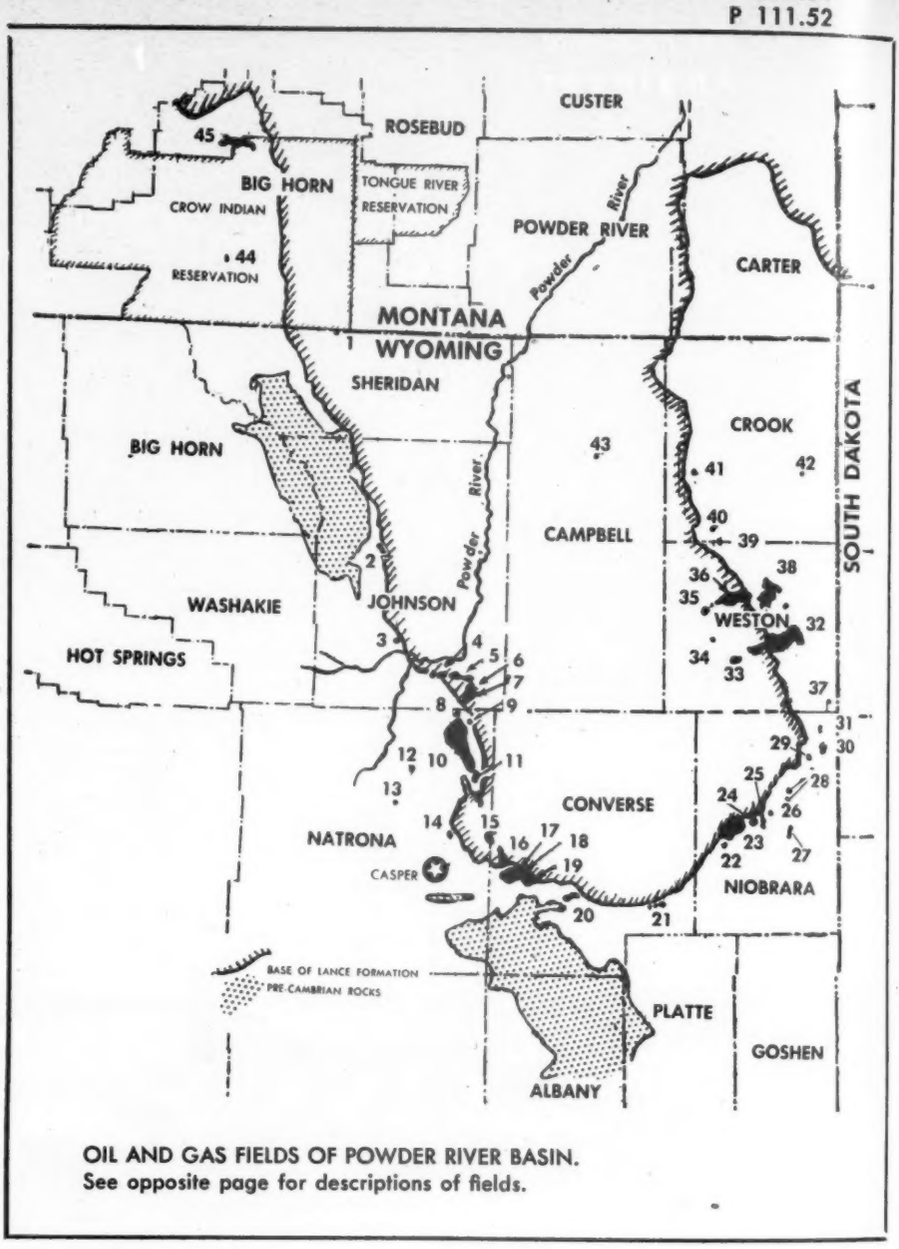


Powder River Basin

W. E. WEST, JR.

Since oil was discovered here in 1889 production has been found in such a variety of traps that there is no doubt this is another great AREA OF PROMISE

Lonely wealth of the Powder River Basin is pictured on the preceding page. This is the Meadow Creek area in Johnson County (No. 7 on the map), looking eastward into the basin. Pine-covered hills in the background are in Fort Union formation. On horizon are Pumpkin Buttes (Wasatch and White River formations) where recent uranium discoveries were made.



OIL AND GAS FIELDS OF POWDER RIVER BASIN.
See opposite page for descriptions of fields.

THE Powder River Basin occupies a large part of northeastern Wyoming and extends into the southeastern part of Montana. It takes its name from the famous Powder River which flows northward, draining the western portion of the basin.

The basin is bounded on the east by the broad arch of the Black Hills; on the west by the more precipitous slopes of the Bighorn Mountains; and on the south by the Laramie Range. It is nearly a topographic, as well as a structural basin. The central part of the basin is a great expanse of rolling grassland intermittently broken up by badland topography along the major drainages.

There are more than two score oil and gas fields in the Powder River basin, with oil exploration dating back to the late 1800's. The past several years have seen an accelerated exploration program and the resulting discoveries have established the area as one having tremendous potentialities.

Stratigraphy

The stratigraphy of the Powder River Basin is rather complex. There are many north-south and east-west changes in lithology, time-span, and thickness, and precise correlations from one part of the basin to another are sometimes difficult. The knowledge of the stratigraphy is largely limited to exposures and well sections on the margins of the basin. There are only a handful of deep tests in the Tertiary-covered interior part of the basin which comprises some three-quarters of the total basin area.

Over this tremendous area then we have only a limited knowledge of the stratigraphy. The next few years will see many deep tests drilled in the Tertiary-covered areas, and with these tests will come solutions to the many stratigraphic problems.

Paleozoic Stratigraphy

Cambrian. The greatest thickness of Cambrian rocks occurs along the northern part of the Bighorn Mountains. The name Deadwood is applied to the sequence comprised of a basal sandstone 200 ft thick, a middle shale section 600 ft thick, and an upper limestone unit 100-200 ft thick. This 1000-ft section represents Upper and Middle Cambrian time. The name, Flathead, may be applied to the basal sandstone, the name, Gros Ventre, to the middle shale unit, and the name, Gallatin, to the upper limestone.

The southern Bighorns has a very similar Cambrian section about 900 ft thick. To the south, however, on Casper Mountain, the Cambrian has thinned to 90 ft. The name Deadwood is used here for a sandstone and conglomerate sequence which is probably upper Cambrian.

In the northern Black Hills the type Deadwood section is about 370 ft thick and is made up of predominately sandstones and shale. Thinning takes place southward and in the southern Black Hills the Deadwood is only about 60 ft thick. The Deadwood of the Black Hills is Upper Cambrian age.

Cambrian rocks have, as yet, produced no oil or gas in the Powder River Basin.

Ordovician. Ordovician rocks are present only in the northern part of the basin. The Bighorn dolomite, a massive, gray, fossiliferous dolomite is about 300 ft thick in the northern Bighorns and thins to a wedge edge in the southern

The Author

W. E. West, Jr., is a consulting geologist in Casper, Wyoming. He is a native of Wyoming, and a graduate in geology from the University of Wyoming in 1948. He worked as a geologist for Continental Oil Company for three years in the Rocky Mountain area establishing his own office in 1951.

OIL AND GAS FIELDS IN POWDER RIVER BASIN, WYOMING

Map No.†	Field	Discovered	Produces from	Cumulative production as of 1-1-52, bbl	Type of trap	Remarks
1	Ash Creek	1952	Shannon (?)		?	
2	Billy Creek	1923	Frontier	3,218,858 MCF	Anticlinal	Gas. Now depleted. Used for storage.
3	North Fork	1951	Tensleep		Faulted nose	
4	West Sussex	1951,52	Shannon		Faulted nose	
5	Sussex	1948	Sussex, Shannon, Frontier Lakota, Tensleep, Amsden	1,970,330	Faulted nose	
6	North Meadow	1950	Sussex, Shannon, Frontier	2,151,739	Faulted nose*	
7	Meadow Creek	1950	Sussex, Shannon, Frontier, Lakota, Tensleep	1,178,851	Faulted nose, Anticlinal	
8	Shannon	1889	Shannon	43,441	Faulted nose	Abandoned
9	East Salt Creek	1951	Frontier, Lakota		Fault	
10	Salt Creek	1906	Frontier, Lakota, Sundance, Tensleep	339,981,550	Anticlinal	
11	Sage Spring Creek, North Sage Spring Creek, East Teapot	1949 1950 1951	Muddy, Dakota	1,034,077	Permeability trap associated with nose	
12	Castle Creek	1947	Frontier	17,533	Anticlinal	
13	North Casper Creek	1925	Tensleep	9,384	Anticlinal	
14	Midway	1931	Frontier, Muddy, Dakota	258,448	Anticlinal	
15	Cole Creek	1938	Shannon, Dakota, Lakota	5,353,634	Anticlinal	
16	South Cole Creek	1948	Dakota, Muddy, Lakota	1,415,655	Anticlinal and Permeability	
17	Big Muddy East Big Muddy	1916	Shannon, Frontier, Muddy, Dakota, Lakota	33,483,857	Anticlinal	
18	Glenrock	1950	Frontier, Muddy, Dakota	581,620	Fault and Permeability	
19	South Glenrock	1950	Muddy, Dakota	1,436,989	Permeability trap associated with nose	
20	Brenning Basin	1902	White River, Dakota (?)	7,052	Permeability. Monocline associated with unconformity	Abandoned
21	Shawnee	1934	White River	1,337	Permeability Monocline associated with unconformity	Abandoned
22	Lightning Creek	1949	Sundance, Muddy	78,165	Fault	
23	Lance Creek	1918	Frontier, Muddy, Dakota, Lakota, Sundance, Minnelusa	87,805,102	Anticlinal	
24	East Lance Creek	1919	Dakota	1,178,463	Anticlinal	
25	Little Buck Creek, South Little Buck Creek	1944	Dakota, Minnelusa	3,166,021	Anticlinal	
26	East Little Buck Creek	1952	Dakota		Anticlinal (?)	
27	Old Woman	1947	Minnelusa	2,801	Anticlinal	
28	Ant Hills, North Ant Hills	1927,48	Dakota	72,476	Anticlinal	
29	Bridge Creek	1950	Dakota	26,207	Fault	
30	Mule Creek	1919	Lakota, Minnelusa	2,372,444	Anticlinal	
31	West Mule Creek	1927	Dakota, Lakota, Minnelusa	126,563	Anticlinal	
32	Skull Creek, Mush Creek, West Mush Creek	1919	Newcastle (Muddy)	5,937,265	Permeability, associated with monocline	
33	Clareton	1950	Newcastle	92,398	Permeability, associated with monocline	
34	Lodgepole	1948	Newcastle, Dakota	10,321	Permeability, associated with monocline	
35	Hay Creek	1950	Newcastle	42,131	Permeability, associated with monocline	
36	Fiddler Creek	1948	Newcastle	7,018,567	Permeability, associated with monocline	
37	Dewey	1936		9,248	Fault	Abandoned
38	Osage, Pedro	1919	Newcastle	6,162,930	Permeability, associated with monocline	
39	Thornton	1915	Carlisle	463	Permeability, associated with Terrace	Abandoned
40	Wakeman	1919	Carlisle		Monocline	Abandoned
41	Moorcroft	1887	Newcastle		Permeability, associated with monocline	
42	Rocky Ford	1909	Minnelusa		Anticlinal	Abandoned
43	Adon	1948	Minnelusa	32,513	Anticlinal	
			MONTANA			
44	Soap Creek	1921	Amsden, Madison	206,178	Anticlinal	
45	Hardin	1913	Upper Cretaceous		Monocline	Gas

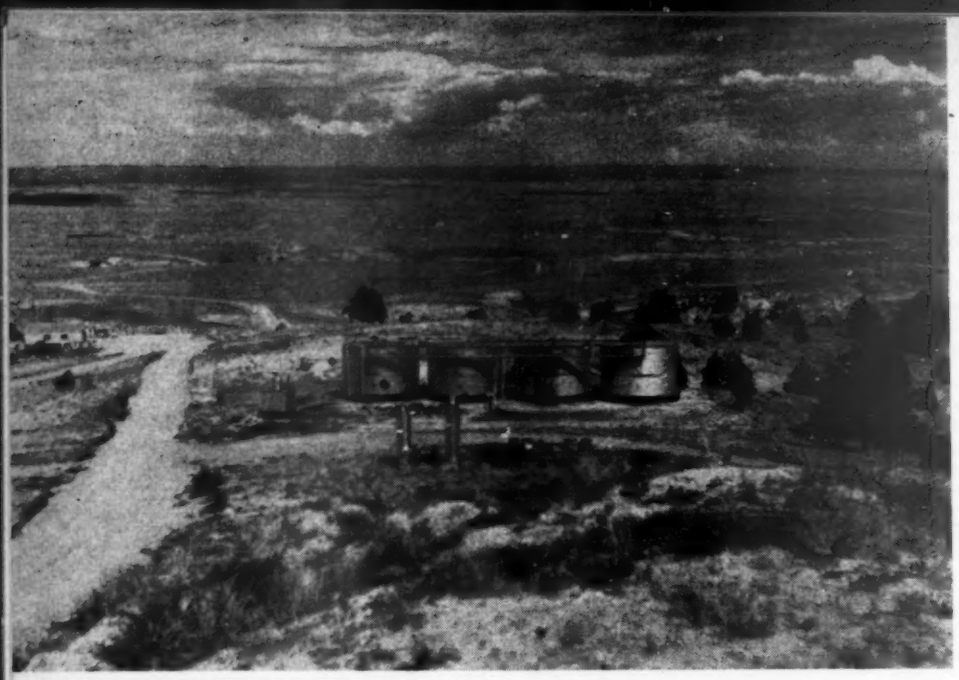
† See opposite page.
* Unless cubic feet of gas is given.

Bighorns. A basal sandstone, 15-25 ft thick containing fish remains is usually present. The Ordovician rocks of the northern Black Hills are composed of a lower sequence of sandstone and shale 75-100 ft thick, the so-called "Whitewood shale", and an overlying dolomite unit, the Whitewood dolomite, about 60 ft thick. Thinning takes place southward and there are no Ordovician rocks present in the southern Black Hills nor in the entire southern portion of the Powder River Basin.

The Big Horn dolomite is considered to be youngest Ordovician in age. The basal sandstone is probably older. The Whitewood dolomite is latest Ordovician while the underlying shale and sandstone unit is Middle Ordovician.

The Ordovician rocks are so far nonproductive of oil and gas in the Powder River Basin.

Silurian and Devonian. There are no Silurian rocks in Wyoming. Devonian



View of Fiddler Creek field, Weston County, Wyoming. Black hills can be seen in in the distance.

rocks are present in Western Wyoming but are not present in the Powder River Basin.

Mississippian. Mississippian rocks are present all over the basin. A southward thinning is evident and is probably due to Pre-Pennsylvanian erosion. The Madison limestone is a cream, thin-bedded limestone having a thickness of about 1000 ft in the northern Bighorn Mountains. It thins to 250 ft in the southern Bighorns and to about 150 ft in the vicinity of Casper Mountain.

The Mississippian of the Black Hills region includes the Englewood limestone, 30-60 ft thick, overlain by the Pahasapa limestone varying in thickness from 300-600 ft.

All Mississippian rocks of the Powder River Basin are considered to be early Mississippian in age (Kinderhook and Osage).

Though Mississippian rocks are important oil producers in other parts of Wyoming, notably the Big Horn Basin, they have not yet produced in the Powder River Basin.

Pennsylvan'an. The Pennsylvanian rocks of the Powder River Basin exhibit sharp facies changes and differences in time-span in different parts of the basin. The Pennsylvanian of the Bighorn Mountains includes the Amsden formation, 200 ft of red shales, sandstones, and cherty limestone, overlain by the Tensleep, 100-300 ft of white to tan, crossbedded, massive sandstone. The age of the Amsden is questionable; some writers preferring to call it Mississippian. Most, however, favor the Pennsylvanian classification. The Tensleep here is probably no younger than Des Moines.

At Casper Mountain there is no Amsden and the Casper formation rests on the Madison. The Casper is about 500 ft thick, the lower portion being composed of alternating sandstones and limestones and the upper 200 ft being light-colored, cross-bedded sandstone. There is evidence that the Casper here is younger in its entirety than the Pennsylvanian of the Bighorn Mountains.

A very marked facies change takes place between Casper Mountain and the Lance Creek region. In the latter area the Pennsylvanian rocks are about 1200 ft thick and composed largely of evaporites. The sequence is called the Minnelusa formation. The Leo sands near the middle of the formation and the Bell sand at the bottom are separated by a succession of alternating dolomites, anhydrites and red shales. Age of the Basal Minnelusa is thought to be Atoka with the upper part of the formation representing the rest of Pennsylvanian time.

The Minnelusa of the Black Hills ranges in thickness from 400-700 ft and is composed of sandstone separated by lesser thickness of dolomite, anhydrites, and red shales.

The Pennsylvanian rocks are productive of oil and gas in the Powder River Basin. The Lance Creek field produces oil from several horizons in the Minnelusa formation. Until recently, the Tensleep along the western margin of the basin had been rather disappointing, even the huge Salt Creek anticline having only a very small Tensleep accumulation. However, the past year has seen important Tensleep discoveries at Sussex-Meadow Creek and at North Fork. Consequently, the Tensleep in this area is now regarded as being a first class objective.

Permian. Permian beds are present all over the Powder River Basin and everywhere consist of a red bed facies of the Phosphoria formation of western Wyoming. Thin limestone tongues of the Phosphoria persist into the Powder River Basin. In the southern and eastern parts of the basin, two lime units are readily recognizable, the Minnikahta, 15-40 ft thick, and the Forelle 12-15 ft thick, above. The two are separated by 60 ft of red shale which is called Glendo. The top of the Permian is somewhere above the Forelle in the Spearfish formation. Below the Minnekahta is the Opeche red shale, about 60 ft thick.

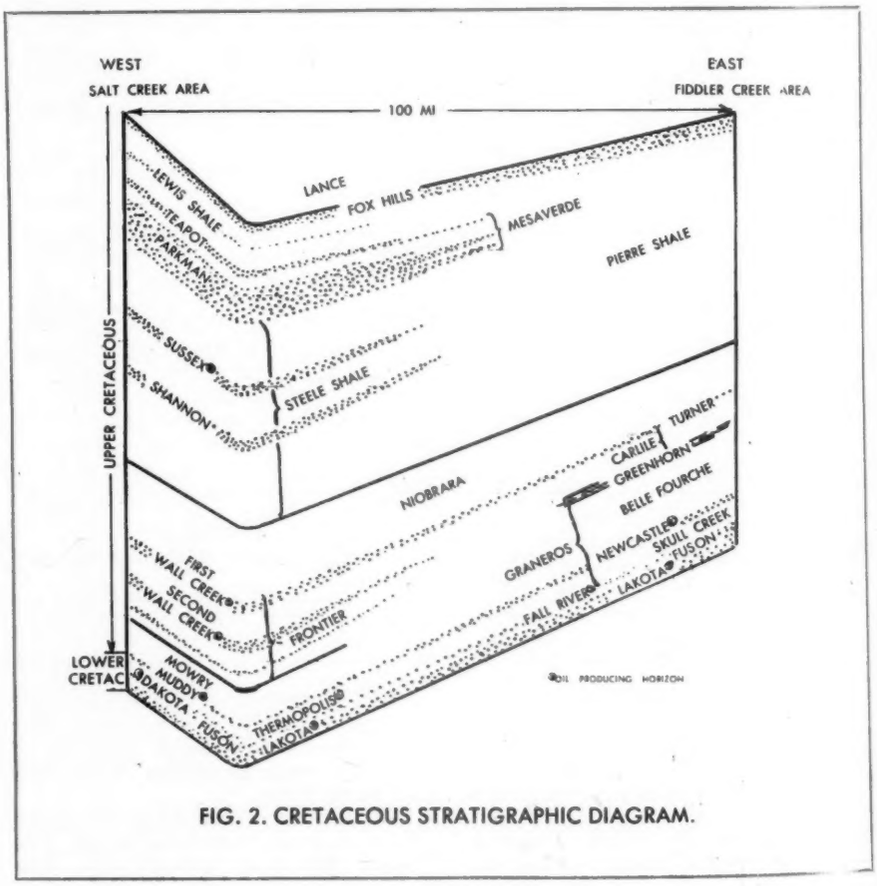


FIG. 2. CRETACEOUS STRATIGRAPHIC DIAGRAM.

The limestones and two separating red shales are remarkably persistant over the southern and southeastern part of the basin. The Minnikahta, at least, is recognizable in the Bighorn Mountains.

The Converse sand in the Lance Creek area, formerly believed to be Pennsylvanian, is now considered Permian Wolfcamp in age. The Converse is an important producer of oil in the Lance Creek field.

Mesozoic Stratigraphy

Triassic. Two names are used in the Powder River Basin to designate the Triassic red beds. The name Spearfish is used in the eastern portions of the basin and the name Chugwater, applied over the rest of the basin. The lower part of this red bed sequence is Permian. The division between the Permian and Triassic rocks cannot be drawn with certainty. There is little lateral change in lithology throughout the basin, the Chugwater or Spearfish always being a monotonous succession of red shales and siltstones with frequent thin beds of gypsum. Thickness varies from 700 to 1000 ft in different parts of the Basin.

Triassic rocks do not as yet produce oil or gas in the Powder River Basin.

Jurassic. Some Lower Jurassic sediments may be present in the basin in the form of the Nugget (?) sandstone of the southern Black Hills and the lowermost part of the so-called "Basal Sundance" of the Lance Creek region. The middle Jurassic Gypsum Springs formation is confined to the northern part of the basin. The Gypsum Springs varies in thickness from 12-45 ft and consists of gypsum and varicolored shales. The Sundance and Morrison formations are everywhere present. Both are upper Jurassic in age. The Sundance is marine and commonly consists of 200-300 ft of gray to green, glauconitic standstones, siltstones and shales. In the southeastern part of the basin, a white to tan porous sandstone up to 140 ft in thickness and occurring at the bottom of the Sundance is called "Basal Sundance."

The Morrison formation overlies the Sundance and consists of about 200 ft of terrestrial deposits: variegated clays and shales with a few thin sandstones.

The "Basal Sundance" is an important producer of oil in the Lance Creek field. The Sundance also produces at Salt Creek.

Cretaceous. Lower Cretaceous rocks include the Lakota, Fuson, and Dakota of the Black Hills region and the equivalent units in the western Powder River Basin. (The name, Fall River, is commonly applied to the Dakota of the Black Hills.) The lower part of the Thermopolis shale and the Skull Creek shale of the Black Hills are also Lower Cretaceous in age and the Lower Cretaceous-Upper Cretaceous boundary is thus drawn at the base of the Muddy (Newcastle) sandstone. The Upper Cretaceous is a sequence of sandstones and shales 6000-7000 ft thick. With but minor breaks, a marine environment prevailed up until Lance time, when the Upper Cretaceous Sea withdrew. The subsequent terrestrial conditions persisted through Tertiary time. The Lance formation consists of loosely consolidated sands and dull colored clays. Average thickness of the Lance in the Powder River Basin is about 1500 ft.

FIG. 3. TECTONIC MAP OF POWDER RIVER BASIN.

Tertiary Stratigraphy

Over 75 per cent of the basin is covered by Tertiary deposits. The Paleocene Fort Union formation is about 2000 ft thick on the west side and consists of fine grained sandstone, light gray shales, and coal beds. The Eocene Wasatch exposures comprise most of the basin's Tertiary-covered area. The maximum thickness of the Wasatch has not been determined but is probably in excess of 2000 ft. Variegated clays, drab colored sandstones, and coal make up the Wasatch. Locally occurring Eocene conglomerates against the Bighorn Mountains in the Buffalo-Sheridan area are called, in ascending order, the Kingsbury conglomerate and the Moncrief gravel.

The White River formation (Oligocene) occurs along the southeast margin of the basin, in the Black Hills, and on the Pre-Cambrian rocks of the Bighorn Mountains. The White River is light colored siltstone and clay, reaching a thickness of at least 500 ft.

Miocene rocks in the form of light-colored, poorly consolidated sands and conglomerate are recognized around the Hartville Uplift.

Tertiary beds have not been important producers of gas and oil in the Powder River Basin. Wasatch and White River sediments, however, contain Uranium deposits at Pumpkin Buttes, in the west-central part of the basin, and coal is mined from the Fort Union formation near Sheridan.

Structure

The tectonic map (Fig. 3) shows the major structural elements of the Powder River Basin. The structural boundaries of the basin coincide closely with the topographic boundaries: Bighorn Mountains on the West, the Laramie Range and Hartville Uplift to the South, and the Black Hills to the East. The northern structural boundary is less definite, but might be considered to occur some 40-50 miles into Montana. The Bull Mountain syncline of South Central

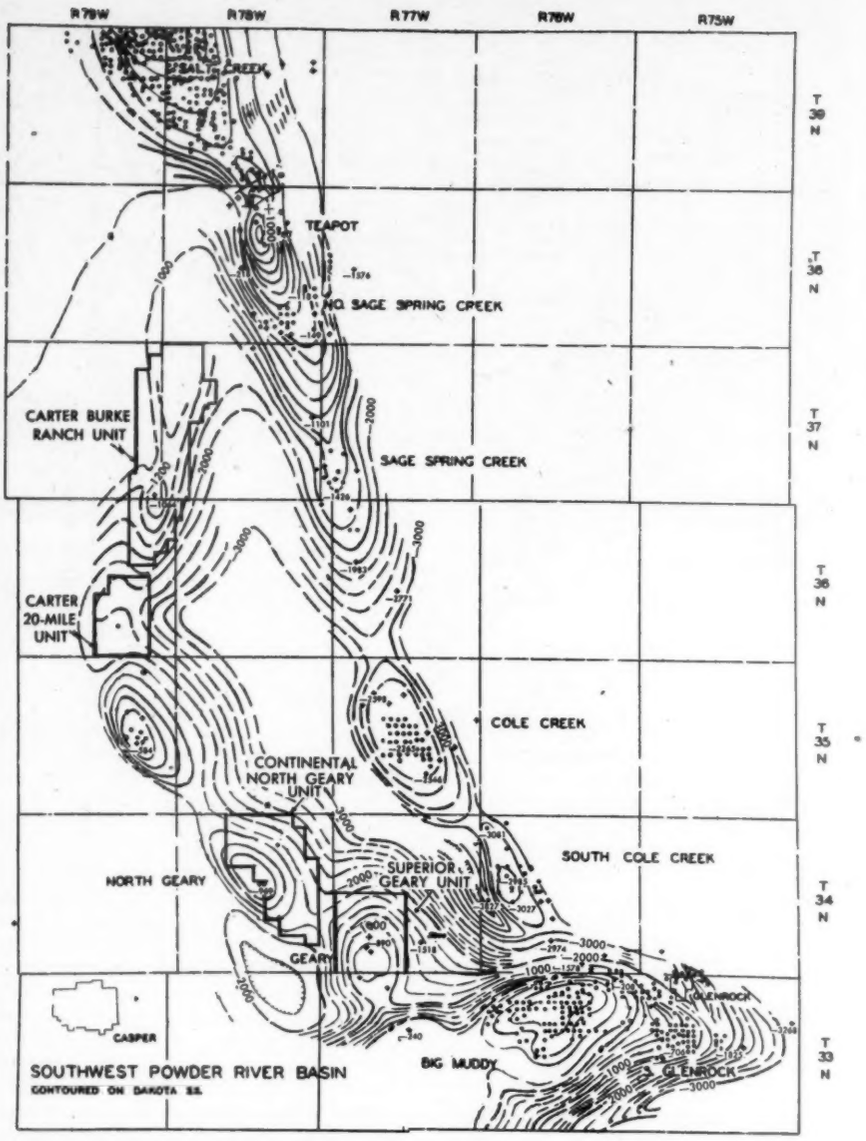


FIG. 4. Southwest Powder River Basin.
(Contoured on Dakota)

Montana may properly be considered a northern extension of the Powder River Basin.

The structure of the basin is rather simple. It is not so strongly deformed as are other intermontane basins to the west. As in the other basins, however, the deeper portions of the Powder River Basin lie next to the higher mountain masses—in this case, the Bighorn Mountains. The highest points on the Pre-Cambrian rocks in the Bighorn Mountains is 13,165 ft above sea level at Cloud Peak. In the deepest part of the basin the Pre-Cambrian rocks are probably in excess of 11,000 ft below sea level.

The northwestern flank of the basin is steepened and overturned. In the vicinity of Buffalo there are thrust faults with displacement of from several hundred feet to three miles. If there be large folds marginal to this steepened area, they are hidden beneath Tertiary cover.

A large transverse feature, the Tensleep-Horn fault, separates the northern segment of the Bighorn Mountains range from a rather structurally different southern segment. South of the Horn fault, a series of en echelon folds are developed along the southwestern margin of the basin.

To the south there are a number of folds paralleling the Laramie Range. Eastward, the folds are influenced and associated with the Hartville Uplift. Besides the larger north-south trending faults of the Hartville Uplift there is evidence of either faulting or sharp flexures peripheral to the southeast margin of the basin. The eastern limb of the basin constitutes a tremendous monocline. While there are a number of folds close to and associated with the Black Hills Uplift, the remainder of the eastern flank is without major deformation.

Deformation in the Powder River Basin took place in late Cretaceous time. There is evidence of deformation in the form of renewed uplift and regional warping in sediments of Eocene and Oligocene age.

Geology and Exploration

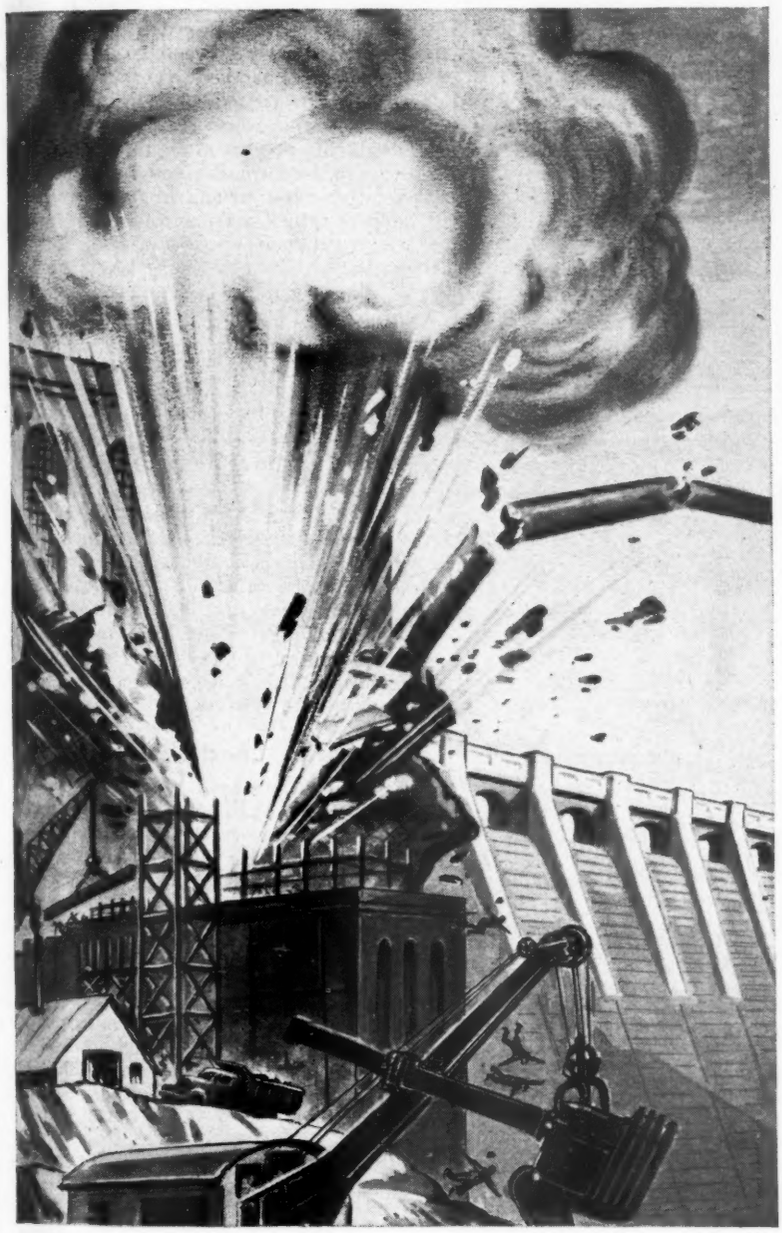
Early exploration was mainly concerned with the drilling of the large closed anticlines, and resulted in the early discovery of three of the basin's major fields: Salt Creek, Big Muddy, and Lance Creek. Stratigraphic accumulations were discovered as early as 1915 in Cretaceous sediments on the east side of the basin. With the exception of this eastern side of the basin, the search for oil has, in the past, involved the locating of structural traps. Since it lacks the scores of surface structures possessed by the Big Horn Basin, the Powder River Basin has not, until the past several years, enjoyed as intense a search for oil as has the neighboring basin to the west. There were disappointments, too. Many large anticlines on the basin margins failed to produce. While geologists realized that the basinward folds had better chances of accumulation and were less subject to the flushing effect of surface waters, the basinward folds were simply not there to drill. Many geologists now share the belief that the folds are present but hidden by Tertiary beds.

The great preponderance of oil discovered and produced has come from the Cretaceous. The Pennsylvanian rocks, extremely important oil reservoirs in other parts of Wyoming were for many years almost unproductive in the Powder River Basin; Lance Creek having the only significant Pennsylvanian production. In 1951 Tensleep discoveries were made at Sussex and North Fork. With these strikes came the realization that large Pennsylvanian reserves are awaiting, at least along the western margin of the basin.

Equally significant has been the recent development in the southwest part of the basin. Permeability traps in the Dakota sandstone have been discovered on the flanks and noses of old well-known structures. The sand conditions responsible for this type of accumulation exist over a large area. The whole of this portion of the basin represents a transition zone in the Dakota with the sand pinching out westward. It seems a certainty that the Dakota productive area will extend westward since the presently productive area is separated from the zero sand isopach by quite a few miles of undrilled landscape. The Muddy sandstone, while more erratic in development, is becoming increasingly important as an oil reservoir in this part of the basin. Stratigraphic production from the Muddy (Newcastle) on the eastern limb of the basin has been known for many years and the more recent extensions of these accumulations have established important new reserves.

The Ash Creek discovery in Sheridan County is important in that it established production in a previously unproductive part of the basin. More than

EXPLOSION RIPS HYDRO-ELECTRIC PLANT IN BRAZIL: 7 INJURED



A vast construction project nearing completion by an American construction company, today was virtually destroyed by an unexplained explosion. Four American technicians and several natives were seriously injured.

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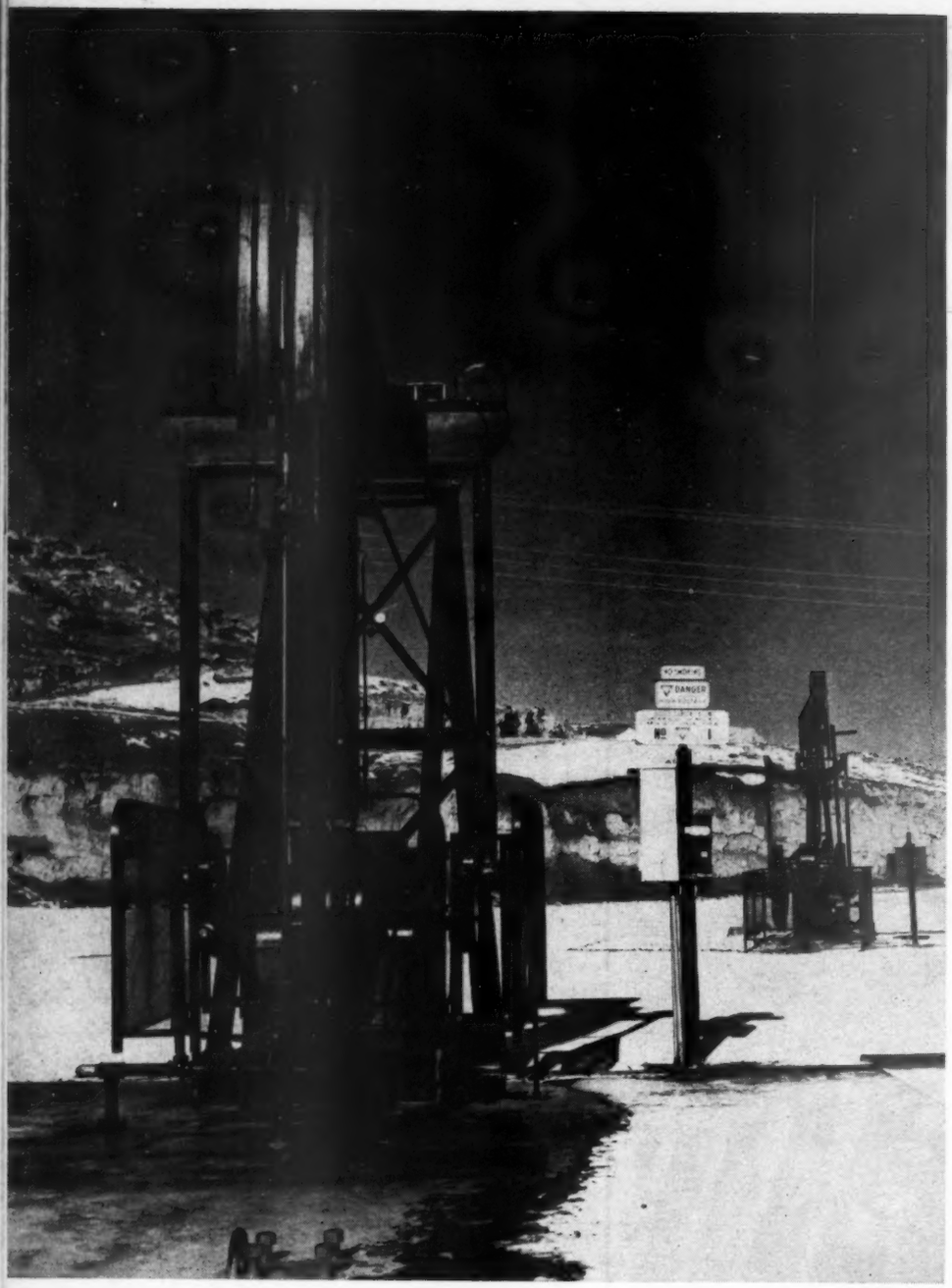

—Photo by C. W. Flood

Discovery of Sussex field, Continental Oil's well in Lakota "A" unit.

that, the new field extended the productive area of the sandy members of the Steele shale to include the entire west flank of the basin. These sands can be a fine bonus for wells drilled in the deeper portions of the basin with ultimate objectives in lower Mesozoic or Paleozoic rocks.

The area lying north and west of Salt Creek and including the Sussex, Meadow Creek, and North Fork fields, is destined to take its place as one of the more prolific oil-producing areas of the Rocky Mountains. Accumulations are almost entirely due to fault traps. The faulting is deep seated. It seems logical to assume that this faulting is genetically related to the Horn fault. In fact, we might extend a broad zone of faulting from Horn fault southeastward to North Fork and the known surface faults on Kaycee anticline; thence more eastwardly, following known surface faults of small magnitude, till we reach the Sussex area. This constitutes a sizable area of interest—an area already outlined by oil fields and with every chance for new discoveries.

Methods of Exploration

Surface geological work has been the most important exploratory tool in the past and will continue to contribute greatly to the search for oil, though not perhaps in such a direct manner. Surface methods will be used to delineate areas for geophysical work. A knowledge of surface geology is important in the southwest part of the basin since the stratigraphic production seems tied in closely with structure.

The large Tertiary-covered interior parts of the basin are a geophysical problem. In such a vast area there must be some way to localize attractive areas. Surface work is possible in some of the Tertiary beds but, for the most part, the structural relief of Tertiary folds is so small that such flexures may be overlooked or not found at all. Gravity methods have been used with some success and would seem a sensible approach to exploration over much of the basin. Gravity, however, must be considered strictly a reconaissance tool—a cheap, quick method to cover large areas and delineate specific localities for seismograph work. The folds are undoubtedly present at depth though probably in the form of broad warpages with relatively low structural relief. We may expect rather sharper folds marginal to the steepened northwest flank of the basin.

The role of the subsurface geologist becomes increasingly important. Subsurface work is now an important tool in the southwest portion of the basin and along the eastern margin. As wells are drilled and information accumulates the Cretaceous sand pinchouts will be localized and their potentialities realized.

Land

About 70 per cent of the land is Federal land. About 10 per cent is State land and the balance is Fee land. Major oil companies and independents have large holdings in specific areas but the lease picture as a whole is not too unfavorable. It is still possible to assemble large blocks of acreage.

Conclusion

Oil and gas fields occur all around the margins of the Powder River Basin with the interior parts constituting an immense virtually unexplored territory.

Oil and gas occurs in sediments as old as Pennsylvanian and as young as Tertiary, with the preponderance of past production coming from the Cretaceous.

The variety of traps, both structural and stratigraphic, in which oil has been found makes us look to the future of this great basin with much optimism. It is an area of promise to be sure—a basin with a future—a first class hunting ground.

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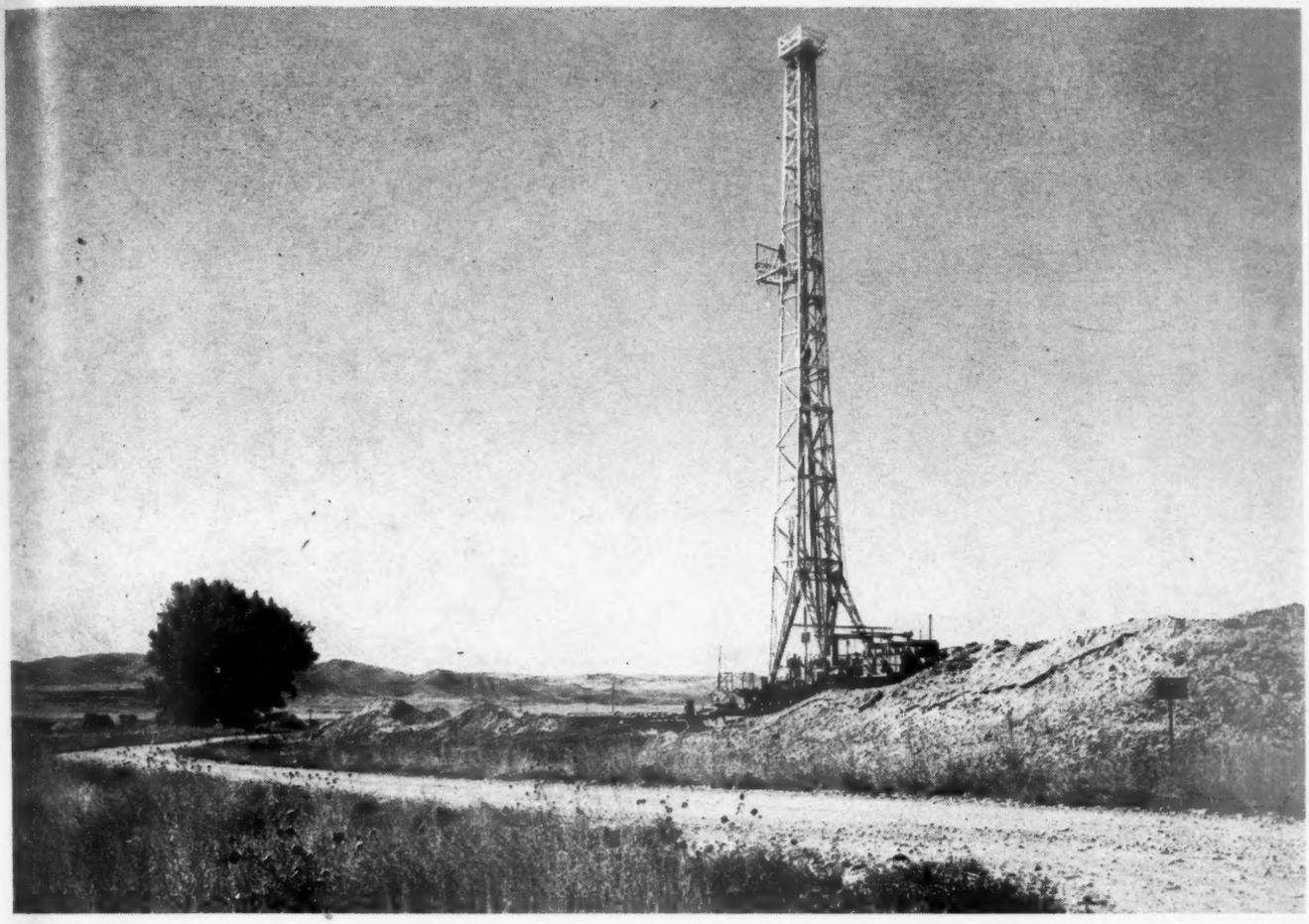


Drilling in the Glenrock field at Far West-Hancock-Continental No. 5 Moffat with Reserve Drilling Company's gas-butane powered rig.

More Oil and More Surprises From Powder River Fields Than Any Rocky Mountain Area

MAURY GOODIN

THE Powder River Basin has supplied more oil—and more surprises for the oil man—than any other area of the Rocky Mountain region since discovery of oil was made in this basin in 1889. During the current exploratory program for the Rocky Mountains the Basin is receiving more than its fair share of the attention. New discoveries during the past four years more than warrant this interest, and wildcats now drilling in the central portion of the Basin could easily start another hectic leasing and wildcat drilling campaign.

Following the discovery of oil in the Shannon pool in 1889, and the subsequent development of production at Salt Creek, the rim of this Basin underwent a period of extensive study for large surface features. These were found at Big Muddy, where discovery was made in 1916, at Lance Creek, on the southeast side of the Basin, where shallow oil was found as early as 1918, and at Osage, on the east side in 1919.

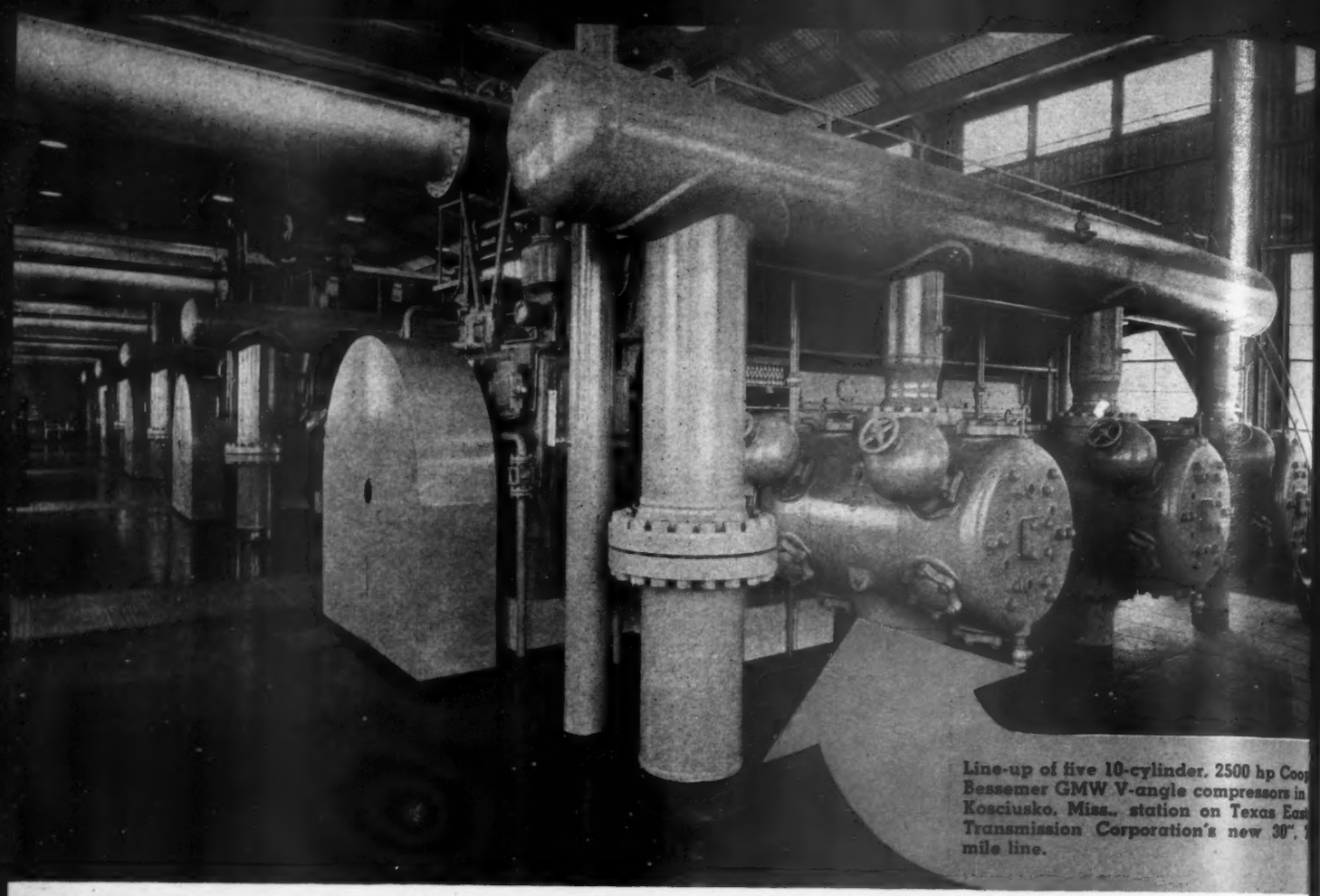
Salt Creek Field

The Salt Creek field discovery brought the first oil field "boom" to the Rocky Mountains and at one time production from this field exceeded 100,000 bbl of oil daily. Production was primarily from the Frontier sands, at depths to 2000 ft. These sands have produced more than 300,000,000 bbl of oil, with the balance of the producing zones—shale, Lakota, Sundance, Morrison and Tensleep—producing approximately 50,000,000 bbl. Production in this field is still above 4,000,000 bbl annually, and although the majority of the acreage in the field is unitized with Stanolind Oil and Gas Company as unit operator, there is still some development drilling. This field has produced more oil than any other in the Rocky Mountain region.

EXCLUSIVE

Teapot Dome

The Teapot Dome area, immediately southeast of Salt Creek, first produced oil in 1922, and during the 3 years the field was developed and produced, more than 3,000,000 bbl of oil was marketed. The field was shut in following the Teapot Dome scandals, however, and there was no activity until 1952, when a Tensleep discovery was made by the U. S. Navy on this Naval Reserve. A second



Line-up of five 10-cylinder, 2500 hp Coop Bessemer GMW V-angle compressors in Kosciusko, Miss., station on Texas Eas Transmission Corporation's new 30", mile line.

Shown here during completion is Un Gas Pipe Line Company's Refugio, Te station containing eight 6-cylinder, 150 Cooper-Bessemer GMW V-angle comp sors.

ANGLE

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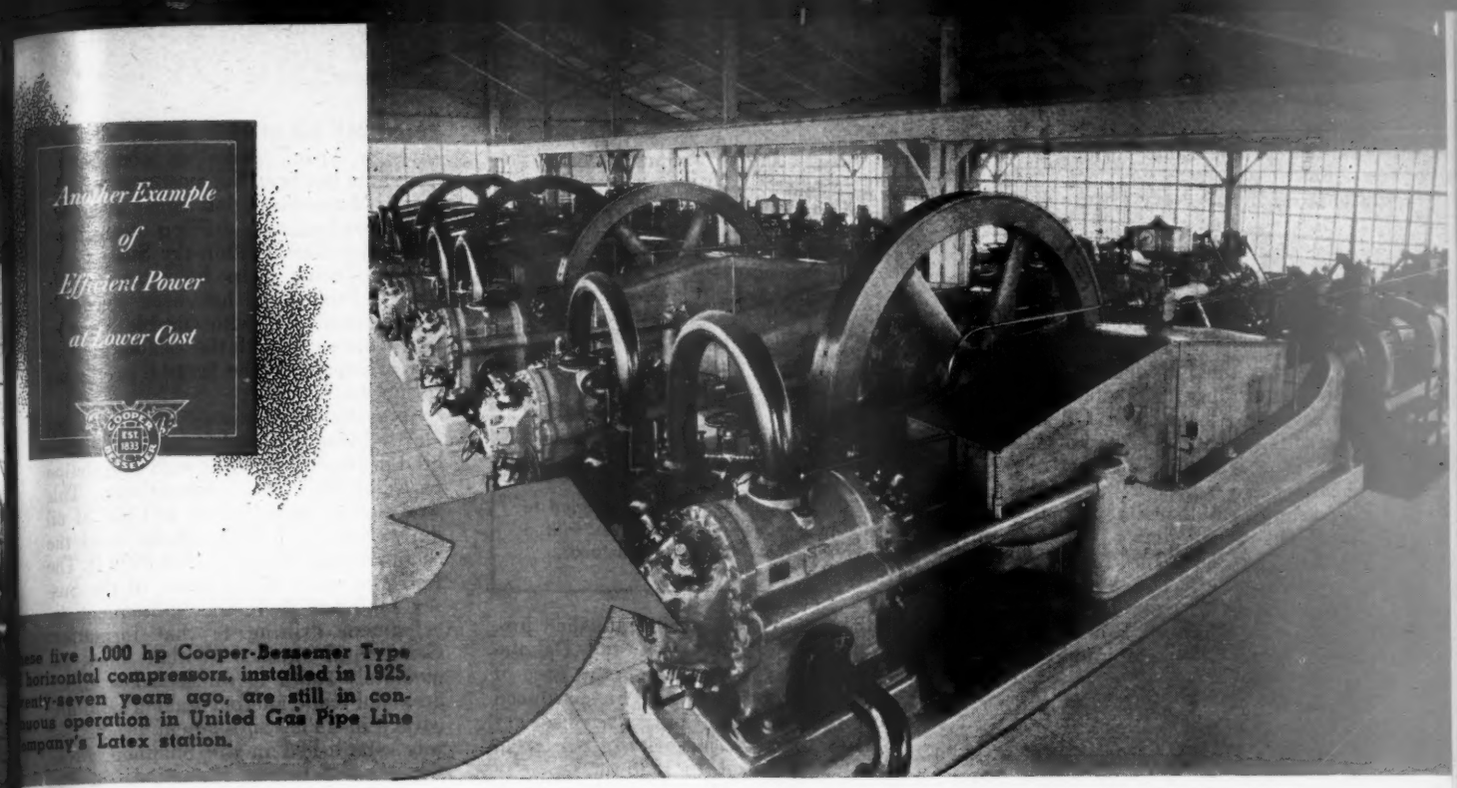
San Francisco, Cal. Houston, Dallas, Greggton, Pampa and Odessa, Texas Seattle, Wash.



...se five 1,000 hp Cooper-Bessemer Type ... horizontal compressors, installed in 1925, ...enty-seven years ago, are still in con... ...uous operation in United Gas Pipe Line ...mpany's Latex station.

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well, a northwest extension, was a failure in the same formation, and a definite program has not been announced by the Navy for the field.

Big Muddy

Production at Big Muddy field maintained a slow, normal decline with more than 35,000,000 bbl of oil produced from the discovery in 1916 until 1946. The majority of this production was from the Shannon, Frontier, Dakota, and Lakota sands with Continental Oil Company controlling the properties. In 1946, however, Dyer Drilling Company of Denver moved eastward, below the field water level, and established a new producing area. This production was subsequently sold to the Southern Production Company and others. Development drilling is continuing to extend the field eastward, with Southern Production, Dyer Drilling and others continuing the drilling program.

Lance Creek

The third large older field in the Powder River Basin is also located along the rim of the Basin, sixty miles southeast of Salt Creek. Primary production was not from the upper zones, as was the case at Salt Creek. Although production was found at Lance Creek in 1919 the productive area for the Dakota was only some 670 acres and production has amounted to less than 1,000,000 bbl since that time. In 1930 oil was found in the Sundance sand and that zone has produced more than 35,000,000 bbl. In 1936 oil was found in the Minnelusa series sands (Pennsylvanian) and 50,000,000 bbl of oil has been produced from some 4800 acres, with gross production still at more than 2,500,000 bbl per year. The total production of some 90,000,000 bbl places this field among the top five in the Rocky Mountains.

East and Northeast Area

During the early stage of exploration in the Powder River Basin the east and northeast sides of the Basin were studied without spectacular results. There was a discovery at Osage field, Weston County, on low closure and more than 650 wells were drilled to the shallow Dakota sands with total production since discovery in 1919 at around 6,500,000 bbl of oil. Initial production of the wells was low and small, independent operators controlled the production, which was processed through local small refineries and products marketed in the area. Other shallow drilling along the east flank failed to find commercial production in this early phase.

A shift in market conditions during the late 1920's, and a drop in flush production at Salt Creek field, resulted in a dormant period in the entire Rocky Mountains that extended through the 1930's. The only developments of importance for the Powder River Basin were the discovery of oil at Cole Creek, and the new pay discovery in Minnelusa at Lance Creek. The Cole Creek field is between Teapot and Big Muddy fields on the southwest flank of the Basin. General Petroleum Corporation, as operator of the Cole Creek unit, established production in the Shannon and Dakota-Lakota zones, with a productive area of some 1650 acres. This field has produced more than 5,000,000 bbl since discovery in 1938, with the majority of this from the Shannon sand. In 1936 the new pay discovery in the Minnelusa series sands at Lance Creek, Niobrara County, was an outstanding development and 150 wells were drilled to that formation at a depth of approximately 5200 ft.

Rocky Mountain oil production, particularly the black oils of the Big Horn Basin in Wyoming, were severely curtailed following the Salt Creek days of the mid-1920's until the beginning of World War II. The light green oils in the southern Powder River Basin lacked sufficient transportation outlet in the early war years to produce at maximum capacities. It was during this period that additional pipe line facilities for the Wyoming area were planned, however, making possible new highs for production for the entire Rocky Mountains. In 1942 the region was producing an average of 115,000 bbl of oil per day with a large proportion of this from Powder River Basin fields. By 1951 this had increased to more than 300,000 bbl daily, with production from the southern Powder River Basin again leading, but curtailed by lack of pipe line outlet.

The early 1940's was a period of renewed exploratory activity throughout the entire Powder River Basin. A large part of this campaign was due to the entry of new operators into the Rocky Mountains. Only a few of the major operators remained in the area during the inactive 1930's and these had sharply reduced exploratory programs. With the increased interest in the Rocky Mountains leasing in the Basin passed all previous records with large blocks assembled by both major and independent operators. Geophysical and geological work increased at a very rapid pace. Wildcat drilling extended throughout the basin with a high discovery rate.

Sussex - Meadow Creek

A major discovery was made immediately north of the Salt Creek field in 1948 when Continental Oil Company found Lakota sand production at a depth of 7700 ft in the Sussex area. The discovery well is a 14,000-acre unit and produced 241 bbl of 39.3 gravity oil daily through ¼-in. choke on completion. This area has been the most active in the Rocky Mountain region from a discovery and development drilling standpoint since that time. Within the Sussex unit two producing areas have been established. Production has been found in four formations, with sizable production from each, with the Lakota sand at the present time the largest producing formation.

Immediately southeast of Sussex the North Meadow Creek pool was discovered in December, 1949, with completion of Delhi Oil's No. 1 Government. This well flowed an initial of 400 bbl of oil daily through 7/64-in. choke from the Shannon sand between 3918-3979 ft. The well also made oil on tests of the Sussex sand and there was subsequent development drilling in that formation. Continental unitized another block immediately south in the Meadow Creek area and made another Lakota sand discovery in 1950. Subsequent production was established in the Shannon, Frontier, and Tensleep formations in this field. Two producing areas have been established at Meadow Creek with development drilling continuing. Another new field was found by Continental in the West Sussex area, 6 miles west of production at Sussex proper, with 2 producing areas in this pool. The discovery, No. 1 Unit had an initial of 450 bbl of 39.5 gravity oil daily from the Shannon sand, after the well was a failure in the Lakota.

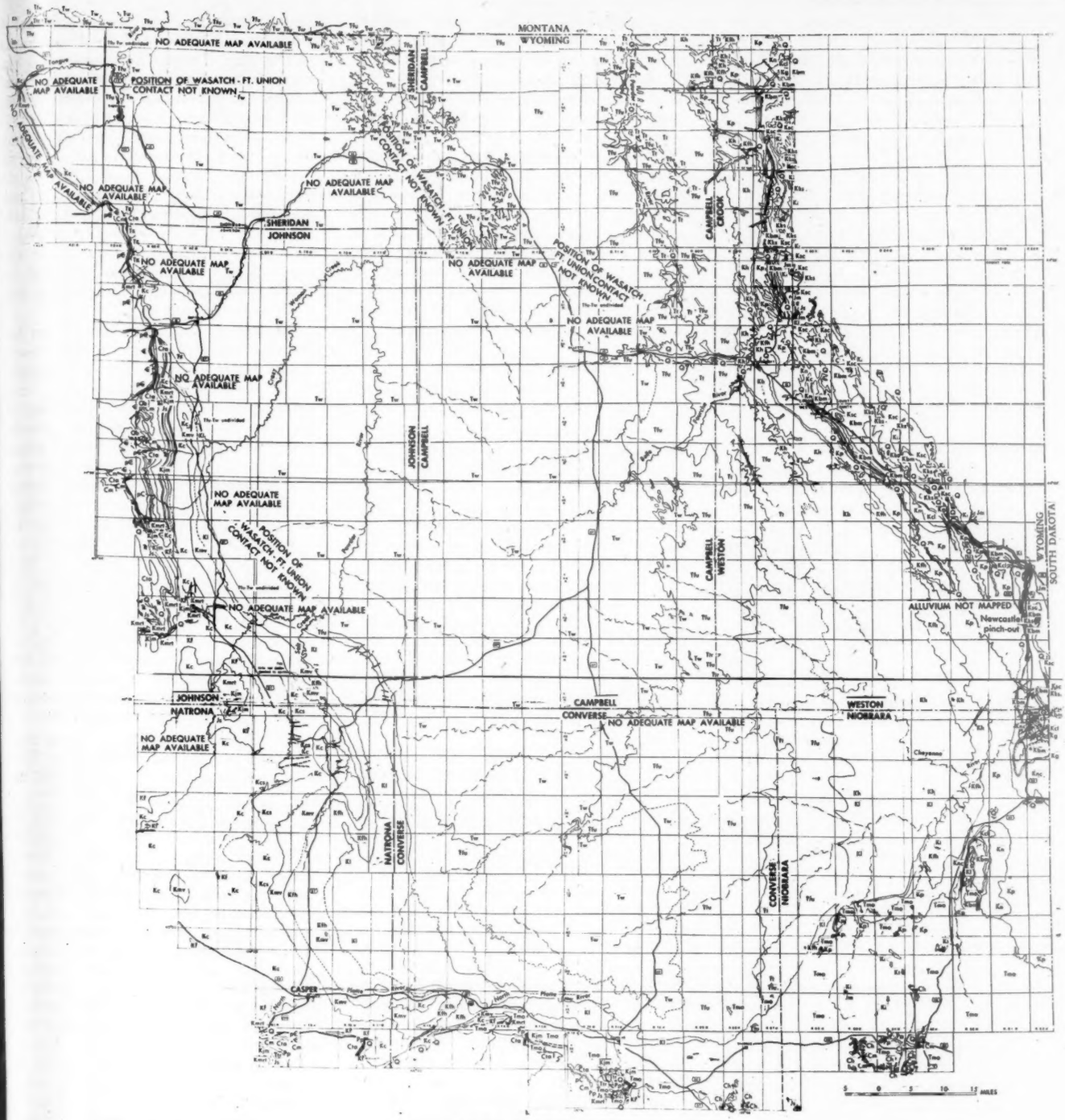
In the general Sussex-Meadow Creek fields, extending over an area trending 15 miles southeast and northwest along the flank of the Basin, there have presently been established 7 producing pools, with production from 5 different formations. A total of 210 wells has been drilled in these pools, and production is now curtailed to 45 bbl per well by reduced pipe line outlet. The wildcat program in this general area is still continuing, although fairly definite outlines of productive areas have been established in the fields proper. Major faulting crossing the axis of the general anticline is believed responsible for the accumulation in the various pools. The discovery of oil in the Tensleep at Sussex in 1951, with subsequent discovery at Meadow Creek, is believed of major importance as a future reserve.

Glenrock

Geophysical work by Phillips Petroleum Company east of the Big Muddy field, in the Glenrock area, was partially responsible for a new discovery here. Steelco Drilling Company of Chicago completed No. 1 McDonald to 7258 ft, below the Muddy, and plugged back for completion in that zone. The well flowed 57 bbl of oil through ½-in. choke in the first hour and settled to 400 bbl of oil daily. The Muddy sand development program in the area later proved disappointing, and it was not until the Dakota sand discovery was made by Phillips in the field that the area indicated sizable reserve. In July, 1950, Far West Oil Company of Casper and San

The Author

Maury Goodin is one of four brothers who own and publish various oil informational services for the Rocky Mountains. The firm, Petroleum Information, was established 25 years ago in Denver and has supplied oil operators of that region with data of the region since. Recently the company added to its Denver and Casper offices with a service office at Billings, Montana.



EXPLANATION:

Surficial Deposits of Quaternary Age

Quaternary

Q—Alluvium and Glacial debris

Sedimentary Rocks

Tertiary

Tmo—Miocene and Oligocene rocks, undivided
Tw—Wasatch formation (Eocene)
Tk—Early Tertiary gravels (including the Kingsbury conglomerate and the Mongrief gravel of sharp)
Ttr, Ttu, Tt—Fort Union formation (Paleocene)

Cretaceous

Kh—Hell Creek formation (Upper Cretaceous)
Kfh—Fox Hills formation (Upper Cretaceous)
Kp—Pierre shale (Upper Cretaceous)
Kmv—Mesaverde formation (Upper Cretaceous)
Kn—Niobrara formation (Upper Cretaceous)
Kc, Kcs—Cody shale (Upper Cretaceous) (Kcs — Shannon sandstone member)
Kcl—Carlile shale (Upper Cretaceous)
Knc—Niobrara and Carlile formations, undivided
Kf—Frontier formation (Upper Cretaceous)
Kg—Greenhorn formation (Upper Cretaceous)
Kbm—Belle Fourche and Mowry shales, undivided (Upper Cretaceous)
Kks—Newcastle sandstone (Upper Cretaceous)
Kgr—Graneros shale (Upper and Lower Cretaceous)
Kmrt—Mowry and Thermopolis shales, undivided (Upper and Lower Cretaceous)
Ksc—Skull Creek shale (Lower Cretaceous)
Ki—Inyan Kara group (Lower Cretaceous)
Kjm—Cloverly and Morrison formations, undivided (Lower Cretaceous and Upper Jurassic)

Jurassic

Jm—Morrison formation (Upper Jurassic)
Js—Sundance formation (Upper and Middle Jurassic)

Triassic

Tr—Chugwater formation (Triassic and Permian)

Permian

Pp—Permian Rocks, undivided

Pennsylvanian

Ch—Hartville formation (Permian and Pennsylvanian)
Cta—Tensleep and Amsden formations, undivided (Pennsylvanian)

Mississippian

Cm—Madison limestone (Mississippian)

Ordovician

Ob—Bighorn dolomite (Ordovician)

Cambrian

e—Cambrian, undivided

Igneous and Metamorphic Rocks

Pre-Cambrian

pe—Pre Cambrian rocks, undivided

GEOLOGIC MAP OF THE POWDER RIVER BASIN, WYOMING*

By J. D. Love and J. L. Weitz, United States Geological Survey

*Published with permission of Director, U.S. Geological Survey.

Antonio, Hancock Oil Company of Long Beach and Continental drilled Well No. 1 State 7, a discovery in the South Glenrock area, Converse County, 2 miles south of production in the Glenrock field. This well flowed 185 bbl of oil daily through choke from the Dakota sand.

Lenticular sand and porosity conditions had previously been indicated responsible for production in the area east of the Big Muddy field and apparently the same sand condition in the Dakota zone accounted for accumulation through these fields. Subsequent development drilling has proven a very sizable area in the Glenrock-South Glenrock field. There are now 81 wells producing in these 2 fields, with production now curtailed to approximately 75 bbl of oil per day due to market outlet.

Mush Creek - Fiddler Creek

By 1940 the Powder River Basin had undergone thorough study as to surface structures and the flanks of the large Basin had been mapped by numerous geological parties. There had been some seismic studies in the central portion of the Basin, but no drilling had resulted. Little work had been done, or wells drilled, based on stratigraphic traps. In 1943 Morton Drilling Company of Casper made a discovery in the Mush Creek area, Weston County, on a nosing from the Black Hills into the center of the Basin. Subsequent discoveries were made at Skull Creek, immediately east of Mush Creek, at Fiddler Creek, Hay Creek, West Mush Creek, Lodgepole, and later at Clareton. Each of these fields are within a radius of 25 miles south and west of the town of Newcastle. Production is from the Newcastle sands (Dakota), varying in depth from 3000 to 6000 ft. Initial production varied considerably, depending upon sand thickness, development and porosity. The Fiddler Creek field will apparently have the largest recovery per acre of the group of fields discovered in this area.

The majority of operators in this Mush Creek-Fiddler Creek area were independents. The Texas Company, Continental Oil Company, and others, however, joined in the lease acquisition program and drilled wells. Production reached a high of 11,000 bbl of oil per day from the fields, and has declined somewhat from that top. Plains Pipe Line Company of Newcastle built a gathering system and pipe line from the area to the Lance Creek station of Rocky Mountain Pipe Line Company where the oil is delivered to eastern and southern refinery centers. Drilling activity has slowed considerably in the fields during the past year, with the exception of the Clareton field where production was found in 1950. A number of operators drilled wildcats both north and south of the Mush Creek-Fiddler Creek area in an effort to establish production on similar noses from the Black Hills, but all wells to the present time have failed.

Sage Spring Creek

Between the Teapot and Cole Creek fields Amerada Petroleum Corporation in 1949 made a Dakota sand discovery on the 30,500-acre Sage Spring Creek unit, along the west flank of the Basin. Although initials on early wells drilled was low, Amerada continued development drilling at a regular, moderate pace. In 1950 discovery was made at North Sage Spring Creek, and Southeast Teapot, also in the Dakota sand and production initials were sufficiently higher in this area, which combined with a diverse lease ownership in the area to make a more rapid drilling campaign. Production in this area is apparently partially controlled by sand development, as several dry holes were drilled, as well as excellent producers.

South Cole Creek

South Cole Creek field was discovered in 1948 with completion of Phillips Petroleum Company's No. 1 Cole, immediately southeast of the Cole Creek Unit. This well flowed 149 bbl of oil through 12/64-in. choke daily for completion in the Lakota sand. The company has continued a development drilling program in the field, with production in the Dakota as well as Lakota sands. In 1950 Ralph Lowe of Midland, Texas, drilled a discovery immediately east of the South Cole Creek Unit, with completion in the Dakota sand. In 1951, the same company made a Muddy sand producer immediately west of the Phillips Unit. This well was a small producer with little development drilling following.

Two important wildcats along the west flank of the Basin have served to move the wildcat program further northward in Wyoming, and along the west rim of the Basin in Montana. This area had been of little interest to operators, although the Billy Creek gas field—now depleted—was discovered in 1923. That field has small gas production from the Frontier sands. Stanolind-Continental in 1951 made a surprising Tensleep discovery at No. 1 Government-Mains, in the North Fork area, northern Johnson County. Tensleep had not been considered too prospective for oil production in the Powder River Basin, although a small producing area was established in this formation at Salt Creek and subsequent production was discovered at Sussex-Meadow Creek. The well flowed 173 bbl of 21.1 gravity oil daily through tubing for completion from that formation. Sands in the Cretaceous, considered more prospective, failed to produce.

Ash Creek

Adding additional interest to this west flank of the Basin was completion early in 1952 of the J. Ray McDermott and Company discovery at Ash Creek, Sheridan County, only one mile south of the Montana State line. This well had an initial of 300 bbl of oil with 20 per cent water in 48 hr from the Shannon 4746-50 ft. The company has continued development drilling since the discovery, with 3 additional producers.

In each of the above cases, drilling—and subsequent discoveries—were along the flanks of the Basin. There had been few wells drilled in the Tertiary covered areas extending from the towns of Douglas, Glenrock, and Lusk northward to the East-Central Montana area. Sinclair Oil and Gas Company created some additional interest in Basinward drilling with completion of a discovery in 1951 in the area immediately east of the Salt Creek field. Production was from the Lakota and Second Wall Creek in the dual completion of No. 1 East Salt Creek and the well flowed 48 bbl of oil daily from the Second Wall Creek with a swab gage of 203 bbl of oil in 21 hr from the Lakota. Development drilling has shown that the field will apparently have a small producing area.

The only discovery to the present date in the central portion of the Powder River Basin is The Texas Company's Adon well, which produced a small amount of oil from the Minnelusa, but was non-commercial. Offsets to the discovery were dry holes and no oil is marketed from the field at the present time. The well was located following seismic work in the area by Texas. Other than a few important failures that were drilled to lower Cretaceous in the southern portion of the Basin—at Shawnee, North Glenrock, North Big Muddy, along the west side at Smith's Cut and Reno Hill, and a few in Powder River, Custer, and Rosebud counties, Montana—the central portion of the Basin has had little exploratory drilling. This is surprising in view of extensive seismic studies by various operators of the region.

With present market problems nearing solution by the Platte Pipe Line, with completion of the 100,000-bbl line now scheduled for December, 1952, it appears that the wildcat campaign for the Powder River Basin will become even more intense. Attention in leasing has been sharply focused to the central portion of the Basin in both Wyoming and Montana. The Williston Basin leasing program did not stop within confines of the Basin but moved very rapidly southward through Custer, Rosebud, Powder River, Big Horn, and Custer counties in Montana, joining the lease play that had moved northward with new discoveries in Wyoming. This resulted in large lease blocks held by independent operators as well as major companies. These blocks are now undergoing processing, geophysical studies, and evaluation. As a result it seems very certain that the Powder River Basin will have an extremely active period during the next several years. Two wells now being drilled in the Wyoming portion of the Basin may well add impetus to this program if they should find commercial production. These are the Pure Oil Company Schoonover test at No. 1 Unit, Johnson County, which is below 10,000 ft and plans to test Lakota at around 11,000 ft, and the Gulf Oil Corporation No. 1 Davis, Campbell County, which is below 7000 ft, and will test Madison at around 10,000 ft.

Regardless of the outcome of these two tests, and others planned for the Montana portion of the Basin, the Powder River Basin will continue as one of the most important from an oil standpoint in the Rocky Mountain region. ★

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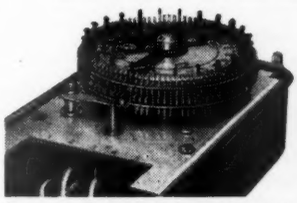

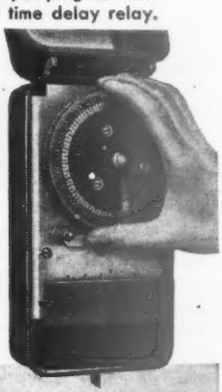

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Characteristics of Crude Oils from the Powder River Basin

W. J. WENGER* and W. J. LANUM*

During the past four years, some major oil discoveries have been made in the Powder River structural basin in Wyoming. Oil is being produced from formations of Cretaceous, Jurassic, Pennsylvanian and Mississippian periods. Most of the recent discoveries have been made in Cretaceous formations and these are the major source of oil at present. Many oil samples from the basin have been collected and analyzed by the Bureau of Mines over the past 30 years. Recently discovered Cretaceous oils, as well as those discovered earlier, are all low-sulfur oils. All high-sulfur oils have come from older Pennsylvanian and Mississippian formations. However, low-sulfur oil is being produced from Jurassic and Pennsylvanian formations at Lance Creek.

The oils have two types of correlation-index curves. One type is characteristic of the Cretaceous oils and the other of Pennsylvanian and Mississippian oils. As a whole, the Cretaceous oils are paraffinic and wax-bearing, with a slight concentration of aromatics or naphthenes in the gasoline range. Pennsylvanian and Mississippian oils, as a whole, are more naphthenic or aromatic than Cretaceous oils and contain more asphalt and less wax. The Cretaceous oils are very similar to those from the neighboring Big Horn and Julesburg Basins. Pennsylvanian and Mississippian oils are similar to those from the Big Horn Basin.

PETROLEUM refiners in the Rocky Mountain region have long been familiar with crude oils from the Powder River structural basin. Ranking among the older and larger fields of the region are the Salt Creek and Lance Creek fields. During the past several years, many new discoveries have been made in the basin, and additional ones are anticipated. Among the most spectacular develop-

*Chemist, Bureau of Mines, Laramie, Wyoming.

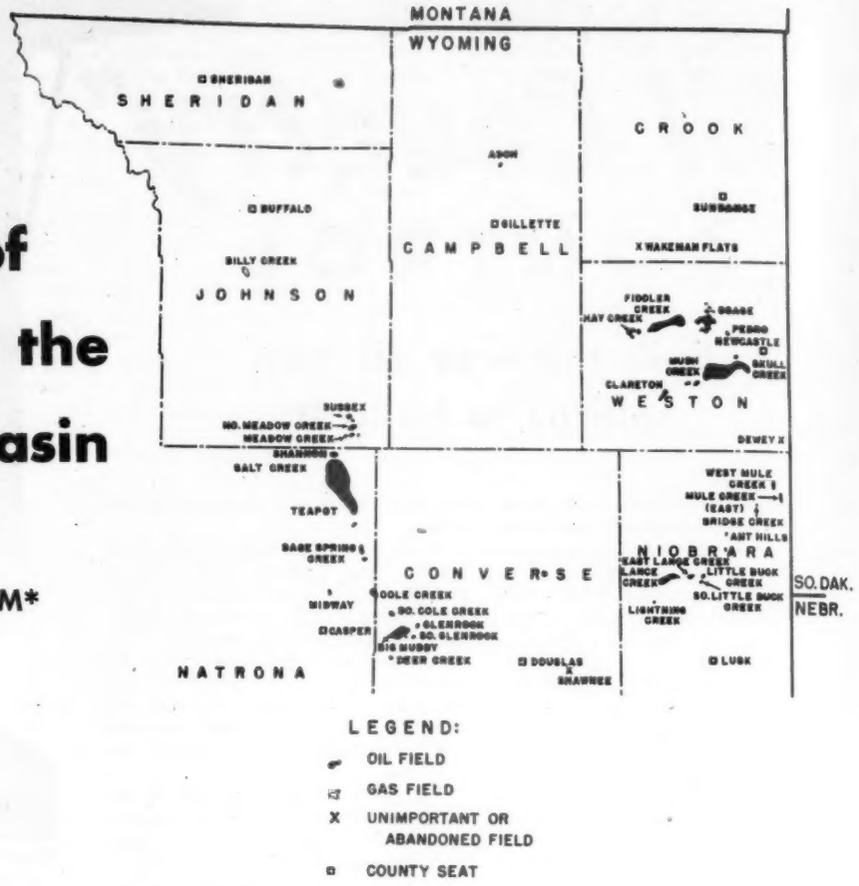

FIG. 1. Oil and gas fields of the Powder River Basin in Wyoming.

TABLE 1. Routine analysis of crude oil from Lakota Sandstone, Meadow Creek (Sussex Area) Field, Johnson County, Wyoming.

Identification	General characteristics	
Sample PC-50-280	Specific gravity	0.816
Meadow Creek (Sussex area) field	API gravity	41.9
Latoka sandstone, Cretaceous	Sulfur, %	<0.10
7,458-7,532 ft	Pour point, F	45
Johnson County, Wyoming	Color	Brownish-green
	Viscosity, SUS at 100F, sec	37

Distillation, Bureau of Mines routine method

Stage 1—Distillation at standard pressure, 760 mm Hg absolute
First drop, 29 C. (84 F.)

Fraction number	Cut at °C.	Cut at °F.	%	Sum, %	Specific gravity, 60/60 F.	API gravity, 60 F.	C.I.	Aniline point, °C.	S.U. visc., 100 F.	Cloud test, °F.
1	50	122	1.6	1.6	.651	85.9	..	....	..	..
2	75	167	3.7	5.3	.674	78.4	9.4	56.3	..	..
3	100	212	5.0	10.3	.718	65.6	20	53.6	..	..
4	125	257	8.0	18.3	.743	58.9	23	51.0	..	..
5	150	302	5.8	24.1	.762	54.2	25	50.6	..	..
6	175	347	5.7	29.8	.777	50.6	25	52.5	..	..
7	200	392	4.9	34.7	.788	48.1	24	57.4	..	..
8	225	437	4.5	39.2	.799	45.6	24	63.6	..	..
9	250	482	5.1	44.3	.811	43.0	24	68.5	..	..
10	275	527	6.0	50.3	.824	40.2	25	72.0	..	..
Stage 2—Distillation continued at 40 mm Hg absolute										
11	200	392	5.5	55.8	.839	37.1	28	77.9	39	25
12	225	437	6.5	62.3	.845	36.0	28	83.6	44	40
13	250	482	6.1	68.4	.858	33.4	30	89.0	54	60
14	275	527	5.1	73.5	.869	31.3	32	94.2	76	80
15	300	572	5.8	79.3	.879	29.5	34	98.8	125	95
Residuum			17.9	97.2	.922	22.0	..	....	..	..

Carbon residue of residuum, 3.1%—Carbon residue of crude, 0.6%

Approximate Summary

	%	Sp gr	API gr	Viscosity
Light gasoline	10.3	.692	73.0	.....
Total gasoline and naphtha	34.7	.743	58.9	.....
Kerosine distillate	15.6	.813	42.5	.....
Gas oil	12.5	.843	36.3	.....
Nonviscous lubricating oil	10.8	.853-.874	34.4-30.4	50-100
Medium lubricating oil	5.7	.874-.884	30.4-28.6	100-200
Viscous lubricating oil	0.0	....	....	Above 200
Residuum	17.9	.922	22.0	.....
Distillation loss	2.8	....	....	.....

EXCLUSIVE

FIG. 2. **Crude-oil-analysis laboratory.** In the background are atmospheric and vacuum distillation units. At left is thermostated bath, with fractions from crude-oil distillations. In center of balance table (right) is a density balance used for obtaining gravities of fractions from distillations. Balances for coarse and precise weighings are also shown.

TABLE 2. Summary of information on crude oils from the Powder River Basin in Wyoming.

PART 1.

Summary of data showing sources and general characteristic of samples.

Item	Field	County	Production formation	Discovery date	Depth, ft	Gravity, API	Color*	Viscosity 100 F., SU sec.	Pour point, °F.	Carbon residue, %	Sulfur, %
			Tertiary Period								
1	Shawnee Creek	Converse	White River	1937	558	24.8	gr.	110	<5	0.8	0.14
			Cretaceous Period								
2	Ant Hills	Niobrara	Muddy	1928	3951–3958	28.7	blk.	..	95	2.8	.14
3	Big Muddy	Converse	Shannon	1916	887–942	34.8	br. gr.	49	<5	1.4	.13
4	Big Muddy	Converse	Wall Creek	1917	3069–3180	35.8	br. gr.	47	15	1.6	.12
5	Big Muddy	Converse	Dakota	1922	4204–4246	35.8	gr. blk.	49	55	1.9	.14
6	Big Muddy	Converse	Lakota	1931	.....	31.7	gr. blk.	64	45	3.1	.17
7	Buck Creek	Niobrara	Muddy	1944	4212–4230	32.7	gr.	70	55	1.7	<.10
8	Cole Creek	Natrona	Shannon	1941	4493–4518	36.3	br. gr.	45	15	1.4	.13
9	Cole Creek	Natrona	Dakota	1943	7947–7962	36.9	gr. blk.	43	50	2.0	.16
10	Cole Creek	Natrona	Lakota	1938	7974–8013	35.0	gr. blk.	52	45	3.2	.19
11	Glenrock	Converse	Muddy	1950	7202–7226	40.4	br. gr.	42	55	1.0	<.10
12	Glenrock	Converse	Dakota	1950	7048–7087	35.0	gr. blk.	49	55	2.4	.11
13	Lance Creek	Niobrara	Dakota	1918	3965–4008	43.8	d. gr.	35	20	.2	<.10
14	Midway	Natrona	Wall Creek	1931	5156–5186	29.5	blk.	160	80	3.4	.34
15	Mule Creek	Niobrara	Dakota	1919	220–240	34.6	br. gr.	56	10	1.1	.13
16	Mule Creek	Niobrara	Lakota	1919	1355	31.5	gr.	77	60	.9	.12
17	Mush Creek	Weston	Newcastle	1944	4167–4215	42.8	gr.	38	<5	.4	.10
18	Osage	Weston	Newcastle	1920	1125	37.6	gr.	50	<5	1.0	<.10
19	Salt Creek	Natrona	Wall Creek	1908	.....	35.6	d. gr.	45	<5	1.0	.16
20	South Cole Creek	Converse	Dakota	1950	8309–8339	35.4	gr. blk.	48	50	2.3	.11
21	South Cole Creek	Converse	Lakota	1948	8285–8324	34.6	gr. blk.	48	45	2.8	.17
22	Sussex	Johnson	Sussex	1950	3920–3954	39.8	br. gr.	37	<5	.9	.13
23	Sussex	Johnson	Shannon	1949	4537–4562	40.2	br. gr.	38	10	1.0	.14
24	Sussex	Johnson	Wall Creek	1950	6360–6397	40.6	br. gr.	38	<5	.7	<.10
25	Sussex	Johnson	Lakota	1948	7698–7726	39.2	br. blk.	41	30	1.7	.35
26	Meadow Creek	Johnson	Lakota	1950	7458–7532	41.9	br. gr.	37	45	.6	<.10
27	North Meadow Creek	Johnson	Sussex	1950	3839–3898	38.8	br. gr.	39	<5	1.1	.12
28	Wakeman	Crook	Wall Creek	1919	610	39.0	gr.	47	<5	1.0	.10
			Jurassic Period								
29	Dewey Dome	Weston	Sundance	1936	988–1017	25.4	br. blk.	200	<5	5.0	.88
30	Lance Creek	Niobrara	Sundance	1930	3794–3903	45.4	br. gr.	36	30	.4	<.10
			Pennsylvanian Period								
31	Adon	Campbell	Minnelusa	1948	8990–9945	30.6	br. blk.	70	<5	4.5	1.20
32	Dewey Dome	Weston	Tensleep	1936	2300–2305	36.0	gr. br.	..	<5	2.4	1.06
33	Lance Creek	Niobrara	Minnelusa	1936	4394–4434	41.5	gr.	54	65	1.1	<.10
34	Mule Creek	Niobrara	Minnelusa	1929	3145–3184	25.6	br. blk.	68	<5	4.8	2.40
35	Salt Creek	Natrona	Tensleep	1930	3775–3802	27.0	blk.	93	<5	6.2	2.25
			Mississippian Period								
36	Mule Creek	Niobrara	Pahasapa	1934	2820–2830	31.1	br. blk.	48	<5	1.5	1.01
37	Salt Creek	Natrona	Madison	1930	4365–4855	21.6	br. blk.	440	45	10.9	2.66

* Colors of crude oils are designated by following abbreviations: gr., green; d. gr., dark green; br. gr., brownish green; gr. blk., greenish black; br. blk., brownish black; and blk., black.

ments have been those of the Sussex-Meadow Creek area, the Fiddler Creek-Mush Creek-Skull Creek area, and the Glenrock-South Cole Creek area. Fig. 1 is a map showing most of the fields of the basin.

Analysis of the new oils by means of the standard Bureau of Mines routine analysis[4,5] gives a basis by which these newly discovered oils may be compared with the well-known crude oils of the basin.[2] Summary analyses of 37 oils, including both new and older discoveries, are presented in this report. A complete analysis of an oil from the Meadow Creek field, Table 1, shows the information obtained with the Bureau of Mines method. Fig. 2 shows the equipment used in the analysis.

Because the Bureau, has not as yet analyzed all oils in the basin, no attempt is made to give a complete discussion of all the oils. However, based on the oils analyzed, some generalizations can be made as to the types of oil that can be expected from formations of different geological time. The newly discovered oils, most of which are produced from Cretaceous formations, are shown in Table 2 to be very similar to the older oils produced from the same formations. Thus the various samples from the Sussex field (items 22-25) compare very closely to the sample (item 19) from the Wall Creek (Cretaceous) formations in the Salt Creek field. The oil from the Minnelusa formation in the Adon field (item 31) is similar to previously discovered oils from similar formations, as, for example, Dewey Dome (item 32). However, the oil from the Minnelusa formation in the Lance Creek field appears to be exceptional and should not be used for comparison.

General Characteristics

All oil samples studied by the Bureau of Mines were produced from formations of five geological time periods—Tertiary, Cretaceous, Jurassic, Pennsylvanian, and Mississippian. Table 2 lists 37 oils from various fields in the basin and gives their general characteristics and a summary of analytical data. These oils were collected and analyzed over the past 30 years. Geologically they are distributed as follows: Tertiary 1, Cretaceous 27, Jurassic 2, Pennsylvanian 5, and Mississippian 2. Most major discoveries of recent years have been in Cretaceous formations, which are the major source of oil at present. Also important is oil from Pennsylvanian formations; most of this is being produced at Lance Creek and Salt Creek.

Nearly all the Jurassic oil comes from the Lance Creek field. No oil is produced from Tertiary formations at present.

Properties of the oils and analytical data have been arranged in Table 2 according to the geological time of the formations. Two types of oil are readily discernible. The light gravity, low sulfur oil is commonly called "green oil" in the area, while the heavy, high sulfur oil is commonly designated as "black oil." One definition of black oil (oil having a gravity of 26 API or lower, 2 or

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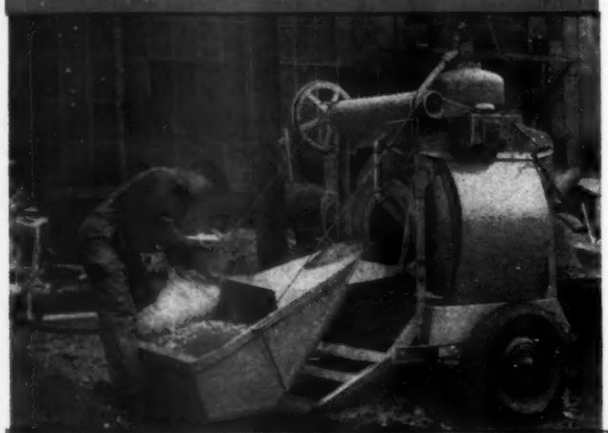

6-S DANDIE concrete mixer with non-tilting, end-discharge drum has power-raised skip, exclusive blade-and-bucket double-mixing action . . . automatic water-measuring system. Tilted Flow-Line Discharge Chute pours full batch in 7 seconds. Other large size Kwik-Mix Dandie concrete mixers include 11-S and 16-S. Send for more facts.

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TABLE 2. Summary of information on crude oils from the Powder River Basin in Wyoming—(Continued)

PART 2. *Summary of analytical and computed data.*

Item	Volume percentages: Fractions 1-3, inc. (light gasoline)	4-7, inc. (naphtha)	8-12, inc. (kerosine and gas oil†)	13-15, inc. (lubricating oil†)	Residuum	Correlation index averages of fractions: 4-7, inc.	13-15, inc.	Specific gravity of residuum
1	0.0	7.0	33.8	28.3	30.9	33	54	0.945
2	0.0	2.4	28.1	25.9	42.9	16	23	.935
3	7.9	17.7	22.9	17.6	32.5	28	38	.934
4	7.7	18.6	23.4	17.1	31.2	26	36	.935
5	6.6	17.1	23.4	18.5	31.6	25	33	.939
6	3.6	16.9	25.9	19.0	34.5	22	35	.958
7	2.6	13.7	26.6	24.2	31.5	23	31	.935
8	6.3	18.6	27.1	19.4	27.1	21	35	.946
9	9.5	19.0	24.0	17.3	26.8	28	37	.951
10	9.6	18.3	22.4	17.8	28.4	21	34	.960
11	10.1	21.6	23.9	16.3	24.9	24	34	.925
12	7.8	17.5	27.3	17.5	29.8	23	36	.949
13	9.7	28.9	29.6	17.6	13.4	17	27	.906
14	3.8	13.2	21.8	18.7	42.0	26	33	.954
15	1.1	16.6	31.8	24.1	26.3	17	31	.927
16	1.4	11.7	27.1	25.4	34.4	21	33	.932
17	12.2	24.6	27.2	17.0	17.0	23	32	.922
18	12.0	24.4	24.4	19.0	18.6	30	33	.918
19	9.2	20.1	26.5	17.6	23.6	31	38	....
20	7.5	18.8	26.5	17.1	28.4	25	35	.952
21	7.8	18.1	25.4	18.0	29.8	23	35	.958
22	12.5	23.1	28.8	17.0	17.7	24	40	.948
23	11.3	22.2	28.3	16.3	20.0	21	38	.943
24	9.9	24.1	27.2	17.2	19.7	25	33	.923
25	8.6	21.7	26.2	16.7	23.7	22	35	.943
26	10.3	24.4	27.6	17.0	17.9	24	32	.922
27	10.6	21.9	26.2	17.7	21.9	23	37	.944
28	10.1	21.5	24.5	18.9	22.3	23	22	.921
29	0.0	8.5	38.5	25.9	25.0	16	45	1.045
30	9.8	32.5	27.0	14.1	14.0	18	28	.908
31	2.2	13.6	30.6	21.3	31.9	14	41	.973
32	13.8	25.9	25.8	16.0	16.2	25	56	1.008
33	10.5	24.7	26.0	16.7	20.5	15	30	.938
34	5.0	16.4	27.6	21.2	29.7	27	57	1.012
35	0.4	14.5	25.7	21.3	37.1	10	42	.995
36	9.1	20.4	27.8	18.5	22.9	22	52	1.009
37	0.0	8.2	26.0	22.1	43.6	16	42	1.025

† Approximate.

more per cent sulfur, and 5 or more per cent carbon residue) would exclude all oils except the Salt Creek Madison sample. Consequently, the oils will be referred to in this discussion as low sulfur and high sulfur oils.

All oils from Cretaceous formations come under the low sulfur classification. Sulfur values range up to 0.35 but most are under 0.2 per cent. Carbon-residue values range from 0.2 to 4.6, with most of the samples showing less than 2 per cent. Many of these oils contain considerable amounts of wax, as indicated by their pour points. There are no significant differences between Upper Cretaceous and Lower Cretaceous oils.

Only one of the Pennsylvanian and Mississippian oils is definitely a black oil, but all except the Lance Creek Minnelusa are high sulfur oils. The black oil was produced from the Madison formation in Salt Creek field (item 37, Table 2). The oil produced from the Minnelusa formation in Lance Creek has a low sulfur content and is similar to Jurassic oils in that respect. Correlation indexes also show a similarity. This green oil may have been transferred to the Minnelusa from younger formations owing to faulting in the Lance Creek field, as suggested by Ball and Espach.[1]

The two Jurassic oils differ from each other in nearly all respects. The Lance Creek Sundance oil is definitely a low sulfur oil. On the other hand, Sundance oil from Dewey Dome is similar to the oils of the Pennsylvanian period. It has a higher carbon-residue value and contains much more sulfur than the Lance Creek sample. The Dewey Dome sample is similar to Pennsylvanian and Mississippian oils from the neighboring Big Horn Basin.

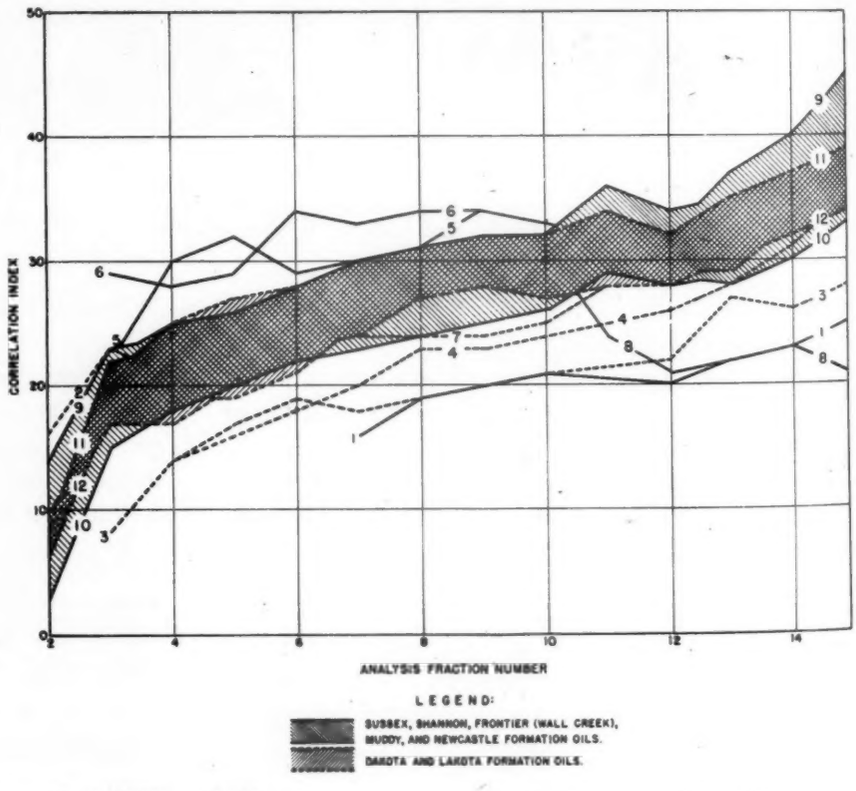
Shawnee Creek oil, the only sample from a Tertiary formation, is green. It appears to be related to the Cretaceous oils from the properties listed in Table 2, yet also resembles Pennsylvanian oils in one respect that will be discussed later under correlation index.

Powder River Basin Oils Compared to Those from Neighboring Areas

The Powder River Basin oils are quite similar to those produced from corresponding formations in neighboring basins. Oils from the Big Horn Basin to the west and the Julesburg Basin to the southeast have been described[1,6], and have properties very similar to the corresponding Powder River Basin oils. These comparisons confirm the unusualness of the Lance Creek production, where low sulfur oil is found in Pennsylvanian formations.

Cretaceous oils from all three basins are found to contain up to 0.3 per cent sulfur and up to 3.0 per cent carbon residue, and for the most part are wax-bearing. In general, the Big Horn Basin oils have slightly lower sulfur contents than those from the other two basins.

Pennsylvanian and Mississippian oils from the Big Horn Basin have high


CORRELATION INDEX
ANALYSIS FRACTION NUMBER
LEGEND:
SUSSEX, SHANNON, FRONTIER (WALL CREEK), MUDDY, AND NEWCASTLE FORMATION OILS.
DAKOTA AND LAKOTA FORMATION OILS.

1	Ant Hills	Muddy	5	Osage	Newcastle
2	Glenrock	Dakota	6	Salt Creek	Wall Creek
3	Lance Creek	Dakota	7	Meadow Creek	Lakota
4	Mule Creek	Dakota	8	Wakeman	Wall Creek
11-12	Band of oils from lower Cretaceous		9-10	Band of Oils from upper Cretaceous	

FIG. 3. Correlation index curves and bands of curves of oils produced from Cretaceous formations in Powder River Basin.

sulfur contents, and many fall in the "black-oil" classification. They have high carbon-residue values and in most cases contain very little wax. There is no Jurassic, Pennsylvanian, or Mississippian production in the Julesburg Basin. Judged by Big Horn oils, the high sulfur oils of the Powder River Basin are of normal type, and the Lance Creek Pennsylvanian oil is exceptional.

Throughout Wyoming[1], green oils are normally found in the younger formations and black oils in the older. This generalization applies to the oils in the Powder River Basin.

Correlation Index

The "green oil-black oil" classification is useful for identifying an oil with respect to appearance, gasoline yield, sulfur content, and asphalt characteristics, which in turn give clues to other properties. Additional information may be obtained from correlation-index[3] classification. The correlation index, although not quantitative, furnishes some knowledge of types of hydrocarbons existing within the oil. The lower the correlation index (CI) values of analysis fractions, the greater the concentrations of paraffin hydrocarbons in the fractions. Likewise the higher the CI values, the greater the concentrations of either naphthenic or aromatic hydrocarbons or both. Both naphthenes and aromatic hydrocarbons are cyclic type hydrocarbons. Straight chain paraffins have a CI value of 0, while benzene has a CI value of 100. CI curves are formed by plotting the correlation index against analysis fraction number. These are

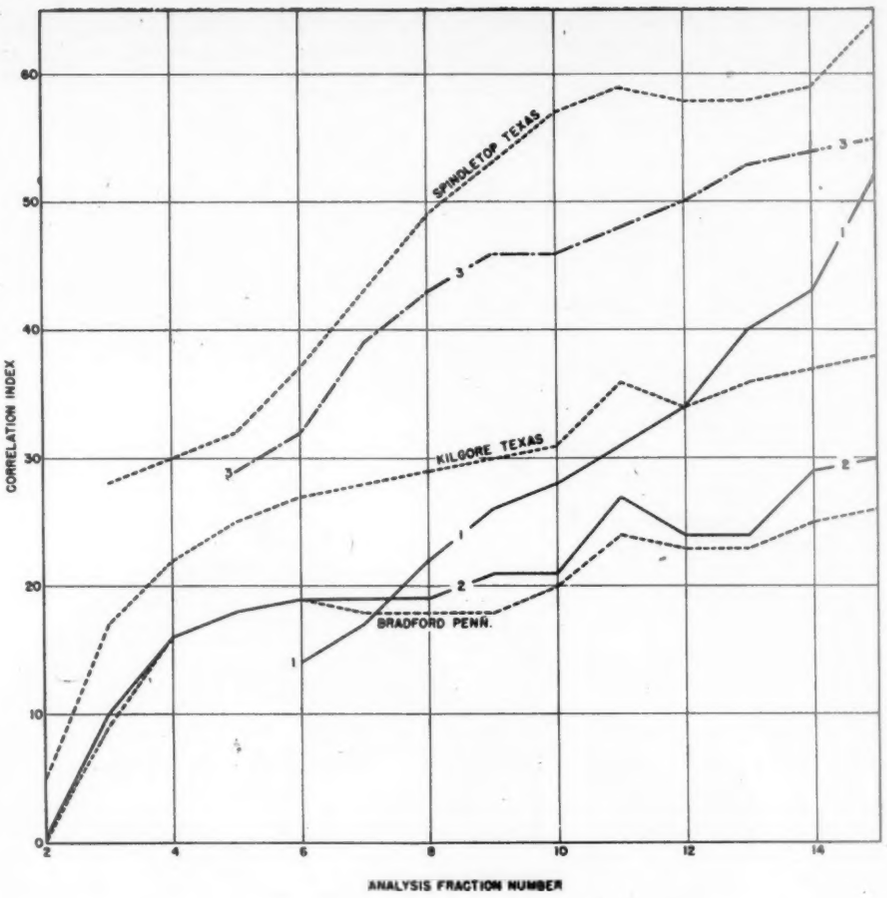


FIG. 4. Correlation index curves of crude oils produced from Tertiary and Jurassic formations in the Powder River Basin and compared to some Texas and Pennsylvania oils.

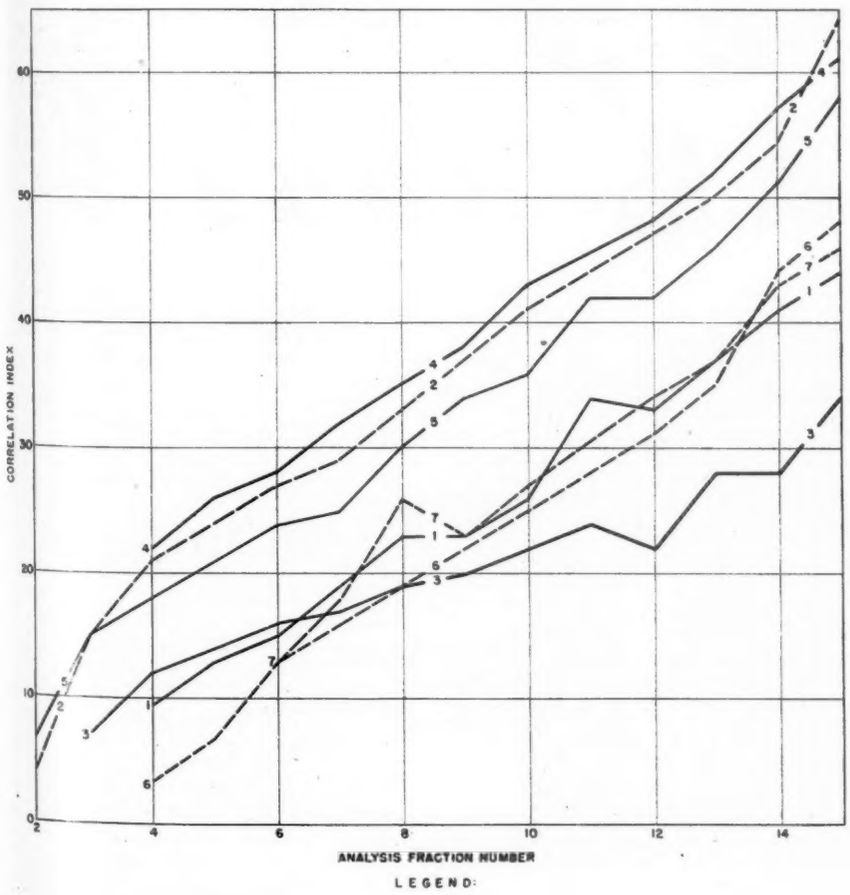

CORRELATION INDEX
ANALYSIS FRACTION NUMBER
LEGEND:
1 Adon field, Minnelusa formation
2 Dewey Dome field, Tensleep formation
3 Lance Creek field, Minnelusa formation
4 Mule Creek field, Minnelusa formation
5 Mule Creek field, Pahasapa formation
6 Salt Creek field, Tensleep formation
7 Salt Creek field, Madison formation

FIG. 5. Left—Correlation index curves of oils produced from Pennsylvanian and Mississippian formations in Powder River Basin.

easily compared to curves of other oils or groups of oils.

Figs. 3, 4, and 5 classify the Powder River Basin oils according to correlation index. Although the curves are far from being identical for oils from producing formations of the same geological time period, the slope and shape of nearly all curves are characteristic for oils of a given period. The majority of the Cretaceous curves in Fig. 3 form a band that can be divided into two bands for

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The Authors

W. J. Wenger

W. J. Lanum

W. J. Wenger is in direct charge of crude oil analysis work at the Laramie, Wyoming, station. He has been with the Bureau of Mines since 1942. He was born in Russell, Kansas in 1916, attended schools in Wyoming, and received a BS degree from the University of Wyoming in 1939. He was employed as a chemist by the Monolith Portland Midwest Company until the latter part of 1942.

W. J. Lanum has been a chemist with the Bureau of Mines since 1948. He was born in Virginia and lived most of his life in Denver, Colorado, where he attended Denver University. He was formerly employed as a development chemist at the Gates Rubber Company in Denver.

Upper and Lower Cretaceous. The two bands are almost entirely superimposed and indicate that Cretaceous oils, whether of Upper or Lower Cretaceous time, are essentially the same. Some oils do not fit within these bands and are indicated as individual curves in Fig. 3. The general shape, slope, and position of curves and bands are also similar to those for Cretaceous oils from the Big Horn and Julesburg Basins. In nearly every case the curves begin with a steep slope in the first part of the gasoline range, then level off and continue with a gentle slope through the lubricating oil range.

Since data are available on only 10 samples, representing oils of Tertiary, Jurassic, Pennsylvanian, and Mississippian periods, and there are some notable exceptions among these, the data are insufficient to define CI patterns as closely for these oils as for Cretaceous oils. Fig. 4 shows curves of the Tertiary and Jurassic oils. The Tertiary oil, although similar in many respects to the Cretaceous oils, exhibits a CI curve more like the Pennsylvanian and Mississippian curves. One of the Jurassic curves, representing Lance Creek oil from the Sundance formation, Curve 2, is very similar to the Cretaceous curves. The other curve, representing Dewey Dome Sundance oil, Curve 1, resembles the Pennsylvanian and Mississippian curves of oils from both the Powder River and Big Horn Basins. Curves representing three Texas and Pennsylvania crude oils are shown in Fig. 4 for comparison. Bradford, Pennsylvania oil is an example of a paraffin-type crude oil; Spindletop, Texas, oil is an example of a naphthenic oil; and Kilgore, Texas, oil is an intermediate oil.

Fig. 5 illustrates CI curves of oils from Pennsylvanian and Mississippian formations. These curves are like similar age oils in the Big Horn Basin with respect to shape, slope, and position. Some are in a much lower position on the CI scale than others, indicating a wide variation in hydrocarbon composition within this group. The oils tend to be paraffinic in the gasoline range, however, with the paraffins decreasing steadily through the ranges of kerosine, gas oil, and lubricating oil fractions. Three oils are almost as naphthenic as Spindletop (Texas) oil in the lubricating oil range. Curve 3, illustrating Lance Creek Minnelusa oil, resembles the curve of Jurassic oil at Lance Creek.

Practical Application of Correlation Index

Refinery processes best suited to certain crude oils may be determined by study and comparison of the correlation index curves. For instance, a peak or hump on the CI curve in the gasoline range indicates a concentration of aromatics, and the gasoline might be a valuable source of aviation base stock, high-octane blending stock, or aromatic hydrocarbons, such as benzene and toluene. A CI value of over 28 on fraction 4 indicates a good source of aviation base stock and a value of over 30 between fractions 4 and 6, followed by a dip in the curve, indicates a good source of toluene. One such peak is exhibited in Fig. 3 (Curve 5) for the Newcastle formation oil from Osage field. Those oils with peaks in the gasoline range yield straight-run gasoline with good antiknock characteristics. Oils with low CI values in the gasoline range would be better sources of solvent naphthas because of their paraffinic nature. The quality of kerosine and diesel fuels depends to a large extent on the concentration of paraffins, since paraffinic kerosine has better burning qualities and paraffinic diesel fuels have higher cetane ratings. Oils with the low CI values in the kerosine and gas-oil range (Figs. 3, 4, and 5) are the better sources of kerosine and diesel fuels.

Paraffin-base oils are generally considered to yield lubricants of the best quality. The Cretaceous oils are more paraffinic in the lubricating-oil range and therefore should be good sources of lubricants. High CI values in the lubricating-oil range, together with high carbon-residue values and low wax concentrations indicate that some of the Pennsylvanian and Mississippian oils would yield quantities of good-quality asphalt.

Acknowledgments

This report represents the results of work done under a cooperative agreement between the Bureau of Mines, United States Department of the Interior, and the University of Wyoming. Acknowledgment is due to M. L. Whisman for making some of the analyses. This investigation was conducted under the general supervision of H. P. Rue, chief, Fuels Technology Division, Region IV, R. H. Espach, chief, Petroleum and Natural Gas Branch, Region IV, Bureau of Mines, and under the direct supervision of J. S. Ball, chemical engineer.

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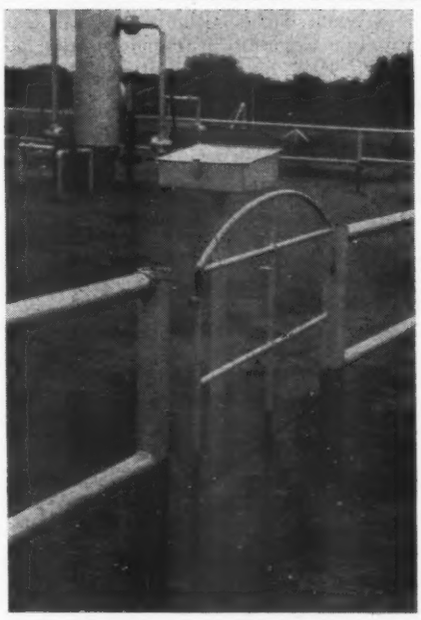

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Petroleum Profile

JOSEPH J. HEDRICK, *President*
Natural Gas Pipeline Company of America,
Texas Illinois Natural Gas Pipeline Company

As a youth of 18, fresh out of high school, Joseph J. Hedrick started his long and interesting career in the oil and gas industry when he started to work as a typist on November 4, 1917, in the land and lease department of the Empire Gas and Fuel Company in Bartlesville, Oklahoma.

He began his new job with a determination to succeed, a virtue that he still possesses regardless of the problem involved. It was not long before this burning desire to make something of himself paid off. Because he was always far ahead of his co-workers in his daily production, it was only a short time until he was noticed by several of his superiors.

This was the turning point of his career, for the next move started him on the long road that would see him wind up as president of one of the greatest natural gas pipe line systems in the country. He was transferred from the land and lease department to the legal department where he began work as a stenographer.

Soon after he started his new job he became vitally interested in the law. His friends and associates in the legal department took a liking to Hedrick and began teaching him legal fundamentals. After whetting his mental appetite on the subject, he realized suddenly that if he was to become a full-fledged lawyer he would have to take organized courses on the subject. He immediately enrolled in a law course with LaSalle Extension University of Chicago.

His legal studies were interrupted briefly in the fall of 1918 when he enlisted in the infantry of the United States Army during World War I. With the end of hostilities and the termination of his military career, he continued his legal schooling. Three years later he received his LLB degree from LaSalle. In June, 1921, he was admitted to the bar in the state of Oklahoma.

He continued his work with the Empire Gas and Fuel Company as one of their attorneys until June, 1930, at which time he became general counsel for Natural Gas Pipeline Company of America and Texoma Natural Gas Company, two newly organized firms.

During the construction period of this new pipe line, he made his headquarters in Kansas City for one year. In June, 1931, his offices were moved to Chicago at 20 North Wacker Drive, where he is still situated as president of this vast natural gas system. In spite of the fact that he was a recognized attorney, he continued his legal studies. In June, 1938, he received his JD degree from John Marshall Law School in Chicago.

His continued diligence in the handling of his job again paid off for on June 18, 1947, he was made vice president and general counsel of Natural Gas Pipeline Company of America and Texoma Natural Gas Company. In December of that year, he was made a director of Natural Gas Pipeline Company and on December 15, 1948, he was made a director of Texoma.

Hedrick became president of Natural Gas Pipeline Company on June 1, 1949, and when Texas Illinois Natural Gas Pipeline Company was incorporated on July 5, 1949, he became president and a director of this new firm.

On June 21, 1951, Natural Gas Storage Company of Illinois was organized as a subsidiary of Natural Gas Pipeline Company of America and Texas Illinois Natural Gas Pipeline Company, formed to develop a huge underground natural gas storage project in the northern part of the state of Illinois. He became president and a director of this new company. On December 19, 1951, Texoma Production Company was incorporated for the purpose of finding and developing natural gas reserves for Natural Gas Pipeline Company. He became president and a director of this newly organized firm.

Having spent the last 34 years in the gas business, Hedrick has earned a national reputation in this field. He is a member of the Gas Industry Advisory Council, which is a branch of the Petroleum Administration for Defense, a director of the Independent Natural Gas Association of America, and a member of the Managing Committee of the Natural Gas Department of the American Gas Association.

His philosophy regarding the more than 1800 employees of the natural gas empire he directs is commended by his many associates for it is his sincere desire to know personally each and every one of his employees. His office door is open to everyone at all times. He is more than glad to listen to the problems of the many people who work for him and to help them in any way possible. He is a strong exponent of sound working conditions, which include the last word in safety, the finest in housing where such projects are necessary, and many other advantages the company can offer to keep employees happy and make them feel that the organization is a good place to work.

Hedrick is married and he and his wife, Lucinda Lee, make their home near Woodstock, Illinois.

Hedrick is a Mason and is a member of the Electric and Chicago Clubs. When he can spare a few moments from his busy life as head of this large natural gas system, he enjoys nothing better than a fishing or hunting trip into the wilderness of our great North America. * * *

Potential of Powder River Basin

The Powder River Basin, a structural syncline, has produced oil for 30 years. Some 35,000 square miles are encompassed within the basin, which sprawls across the states of Wyoming and Montana. Relatively little is heard about the basin these days, but due to certain neighboring discoveries future oil possibilities in the northern section may develop.

To the north the Ordovician formations are about 500 ft thick. Production has recently been discovered in the Ordovician in the Williston Basin, a development that arouses interest in the problem of whether the Ordovician will also be productive in the Powder River Basin. The matter is under serious consideration, and perhaps the drilling bit will reveal the answer in the near future.

Another unsolved problem, to date, is the potentiality of the Mississippian limestone. There have been oil shows, but no commercial production. The operator is presently confronted with conflicting evidence, which resolves into the following queries. What has happened to the oil? Was it there? Is it still there?

Up to the present, oil field development has been confined to the outer rim of the basin. The exploration of the basin proper would call for deep drilling and would be in an area that geologically, and with reference to oil or gas possibilities, may be described as extremely speculative.

Some of the reservoirs are characterized by domes, or, in other words, structural accumulation. Within recent years stratigraphic traps were discovered in the basin. They are a lenticular sand deposit, 10 ft thick, that produce commercially.

In many oil areas paraffinic crudes quite often present operational difficulties, and the elimination or the reduction of the paraffin deposition is necessary. This was the case in the South Glenrock field where a paraffin base oil of 37 gravity is produced from the southern portion of the basin. The employment of a plastic flow line has aided in the reduction of excessive paraffinic deposition. (Flow lines are buried 5 ft deep as a safeguard against the low winter temperatures that occur in the basin.) A heat treatment of 140 F is applied at the tank battery as another process for avoiding any deposition.

Because of the lack of an adequate pipe line outlet the basin is experiencing an enforced curtailment in its production. The Platte pipe line was scheduled for completion this coming fall, but is delayed on account of the steel shortages ereated by the mid-year steel strike. The line will reduce somewhat the present restrictive production practice, but some wells will still have to remain closed-in by necessity.

Although exploration activity in the basin has been reduced and was diverted to the Williston Basin, development of the Powder River Basin continues. Moreover, its petroleum possibilities are far from exhausted, indeed, they are hopeful. —J.M.

advantages of BAKER Stage Cementing

You can save casing by Stage Cementing the Baker way, because with *only* one string of casing you can cement off at the shoe *and* shut off surface water. Or you can cement a well with *two producing zones* and be assured of uncontaminated cement for the upper zone. And you *never* need risk breaking down a comparatively weak formation by high cementing pressure and the extreme weight of a long cement column.

IT'S SIMPLE, SPEEDY AND SAFE to perform two-stage cement jobs with Baker Stage Cementing Collars (Product No. 200-F) in combination with other Baker Equipment. In addition to positive, mechanical closing of the cementing ports upon completion of the second stage, you are assured of these outstanding advantages:

1 After the second stage has been completed, an external steel sleeve with an oil-resistant synthetic rubber seal provides positive closure and prevents passage of fluid between the inside and the outside of the casing, regardless of the condition of the cement job at that point.

BAKER STAGE CEMENTING COLLAR

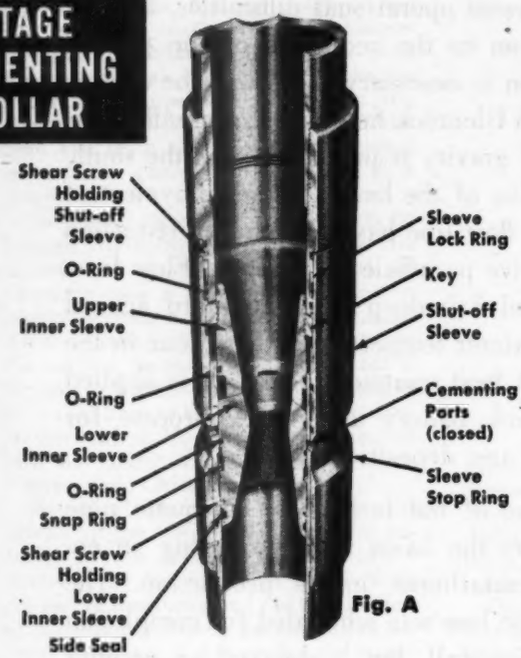


Fig. A

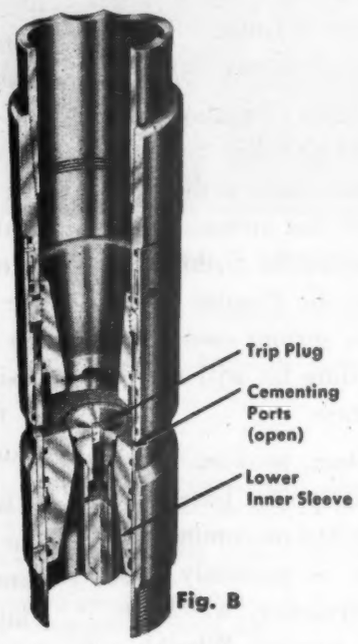


Fig. B

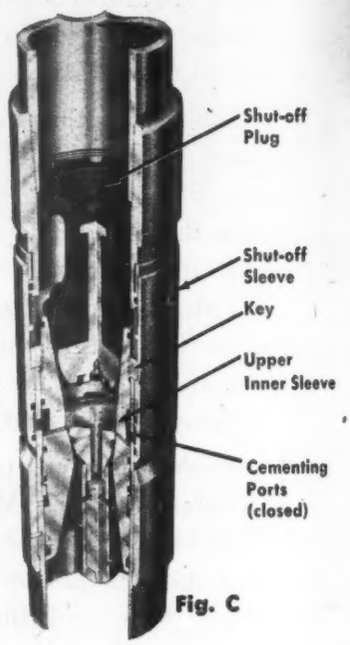


Fig. C

Fig. A—Ready for cementing the first stage. The cementing ports are covered by the Lower Inner Sleeve which is held in position by shear screws; shear screws also hold the Shut-Off Sleeve above the cementing ports. The Baker Flexible Cementing Plug (shown on opposite page) will pass through the Stage Collar without shearing the screws holding the Inner Sleeves.

Fig. B—Ready for cementing the second stage. After the Trip Plug is seated, application of hydraulic pressure shears the screws holding the Lower Inner Sleeve which moves downward, thus uncovering the cementing ports. The Trip Plug prevents passage of fluid into the casing below, and cement pumped into the casing will now pass through the cementing ports for the second-stage cementation.

Fig. C—Second-stage cementation is completed. The Shut-Off Plug has been pumped down the casing and pressure applied to shear the screws and move the Shut-Off Sleeve downward to close off the cementing ports. Note how the Sleeve Lock Ring has expanded to lock the Shut-Off Sleeve in position permanently covering the cementing ports.

See opposite page for details of operation.

2 The cementing ports of the Stage Cementing Collar may be opened at any time after completion of the first stage, and fluid may be circulated through the stage collar for any desired length of time before starting second-stage cementing.

3 Operation of the stage collar is effected by fluid pressure applications only, and no movement of the casing is required after the first stage of the cementation has been completed.

4 All internal parts of the Baker Stage Cementing Collar are constructed of readily drillable materials, and when drilled out there are no sharp shoulders or irregularities to interfere with the subsequent passage of tools through the collar.

5 Since the steel Shut-off Sleeve is on the outside of the Stage Cementing Collar, there is no possibility of accidentally opening the cementing ports when drilling out the internal mechanism, or later when bits or casing scrapers are run through the collar.

Sussex field, Johnson County, Wyoming.

P 410.

Sussex and Meadow Creek Fields

Six pay zones have produced — four additional zones to be developed

FRANK C. SIMS

THE Sussex and Meadow Creek fields lie in the southwest portion of the Powder River Basin five to ten miles northeast of the old Salt Creek field (Fig. 1). The discovery well, Continental Sussex Unit No. 1, in the NW NW SE Section 17, Township 42 North, Range 78 West, was completed in July, 1948, in the Lakota sand at a total depth of 7726 ft for an initial potential of 350 bbl of 41 gravity oil daily. Surface geological reconnaissance followed by gravity and seismos detail initiated the drilling of this well.

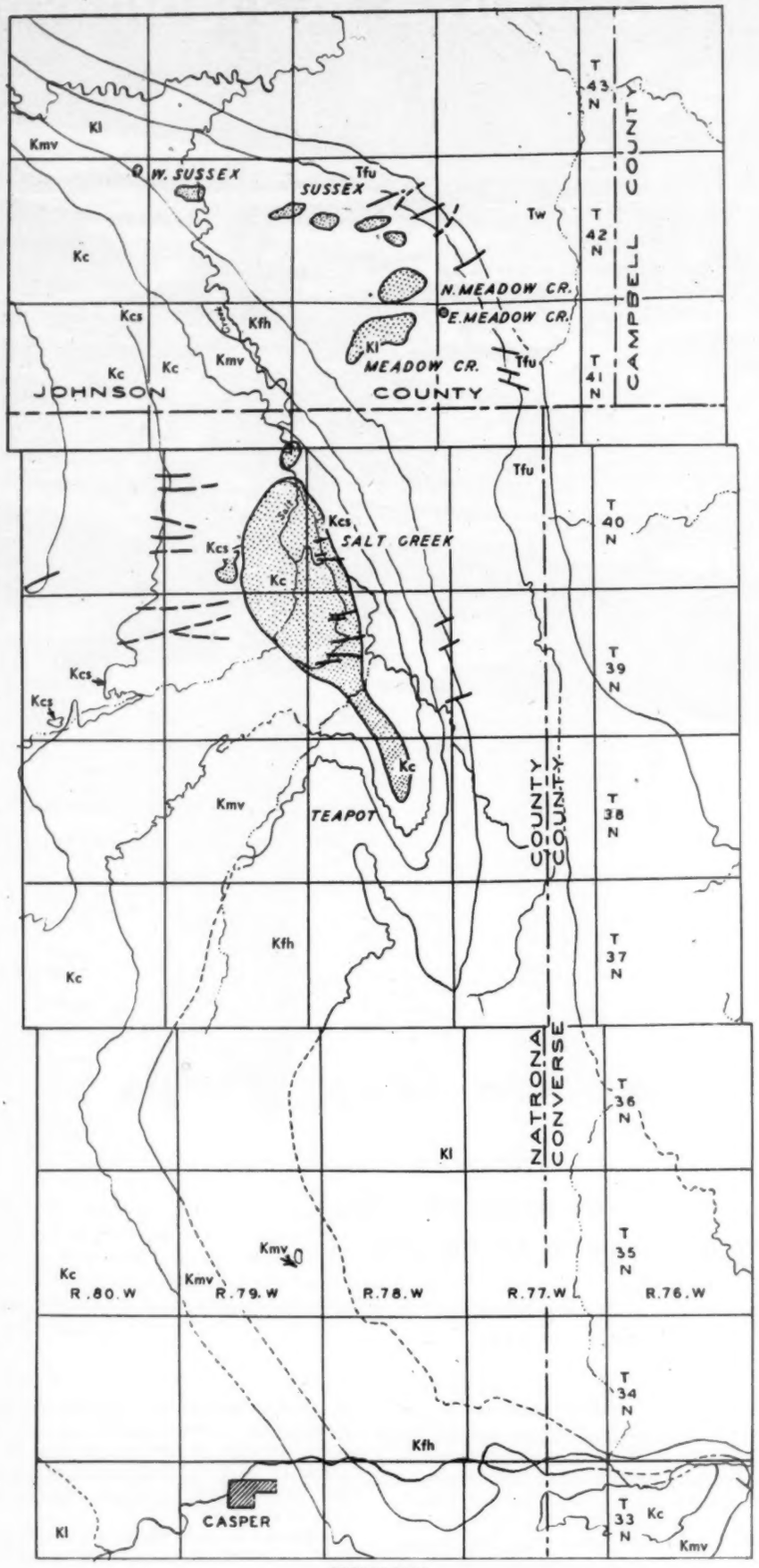
Development

Subsequent development around the drill site led to new pay discoveries in the shallower Sussex and Shannon sands. In May, 1949, a second Lakota pool was discovered 2½ miles to the east. During the same year, Sussex and Shannon sand production was proved in the North Meadow Creek area lying between the Sussex and Meadow Creek Units (Fig. 2). Meadow Creek Unit No. 1, in NE NE NW Section 11, Township 41 North, Range 78 West, was completed in the Lakota sand in April, 1950, for a potential of 240 bbl per day at a depth of 7555 ft. Additional Shannon and Second Wall Creek oil was discovered in this area.

Later in the year, Meadow Creek Unit No. 5 tested Shannon and Lakota oil 1½ miles west of the initial discovery. Also, two sizable Sussex-Shannon producing areas were discovered in the Sussex Unit during this period.

The following year two small pools were proved in the Meadow Creek Unit,

EXCLUSIVE



FORMATION:

Kc	Cody shale (Upper Cretaceous)	Kmv	Mesaverde (Upper Cretaceous)
Kfh	Fox Hills (Upper Cretaceous)	Tw	Wasatch (Eocene)
Kl	Lance (Upper Cretaceous)	Kcs	Shannon sandstone member

(After United States Geological Survey, Oil and Gas Investigations Map O.M. 122, 1951, modified.)

FIG. 1. Geological map of Southwest Powder River Basin, Wyoming.

The Author

Born in Nebraska Frank C. Sims moved to Wyoming in 1934 and graduated from the University of Wyoming with a BA degree in geology in 1943. Following 3½ years in the Army he returned to the University of Wyoming for a masters degree in geology. Sims joined Continental Oil Company in 1948 and is at present regional development geologist for Continental in Denver, Colorado.

one in the Sussex and the other in the Shannon sand. In June, 1951, Sussex Unit No. 59, in SW NW SE Section 17, Township 42 North, Range 78 West, dry in the Lakota, was deepened to 9299 ft into the Tensleep sand for an initial production of 1400 bbl of 30.5 gravity oil per day. To date, two of the original Sussex Unit producing areas have been drilled to the Tensleep sand with success, and one Tensleep pool has been discovered in the Meadow Creek Unit. One of the Sussex Unit Tensleep pools is in an advanced stage of development.

In general, the limits of the Lakota and shallow sand producing areas have been defined in the Sussex and Meadow Creek Units and the North Meadow Creek area, and development drilling has been gradually discontinued. Rapid development during 1951 connected the two original Shannon reservoirs in the Meadow Creek Unit to form one of the larger producing areas.

In August, 1951, West Sussex Unit No. 1, in NW SE NW Section 8, Township 42 North, Range 79 West, 4 miles west of production, was completed at a plugged back depth of 2950 ft in the Shannon sand for an initial potential of 450 bbl of 39.5 gravity oil per day. This well had a total depth of 6160 ft in the Lakota sand and flowed salt water from that formation. Subsequent drilling has outlined the limits of the Shannon pool and, in addition, has discovered a small Lakota producing area. In July of this year another Shannon sand discovery was completed 1½ miles to the northwest; however, due to curtailment of development drilling, size of this prospect has not been determined.

As of July 1, 1952, 226 producing wells have been completed in the Sussex and Meadow Creek areas. Development has been on the basis of one well to 40 acres in the unitized areas; Sussex sand wells in the North Meadow Creek area have been drilled one to 20 acres.

Producing Zones

The Sussex sand is the shallowest of 6 pay zones that have thus far been produced. Four additional zones which have tested oil remain to be developed. Meadow Creek Unit No. 98 (Fig. 3) deep

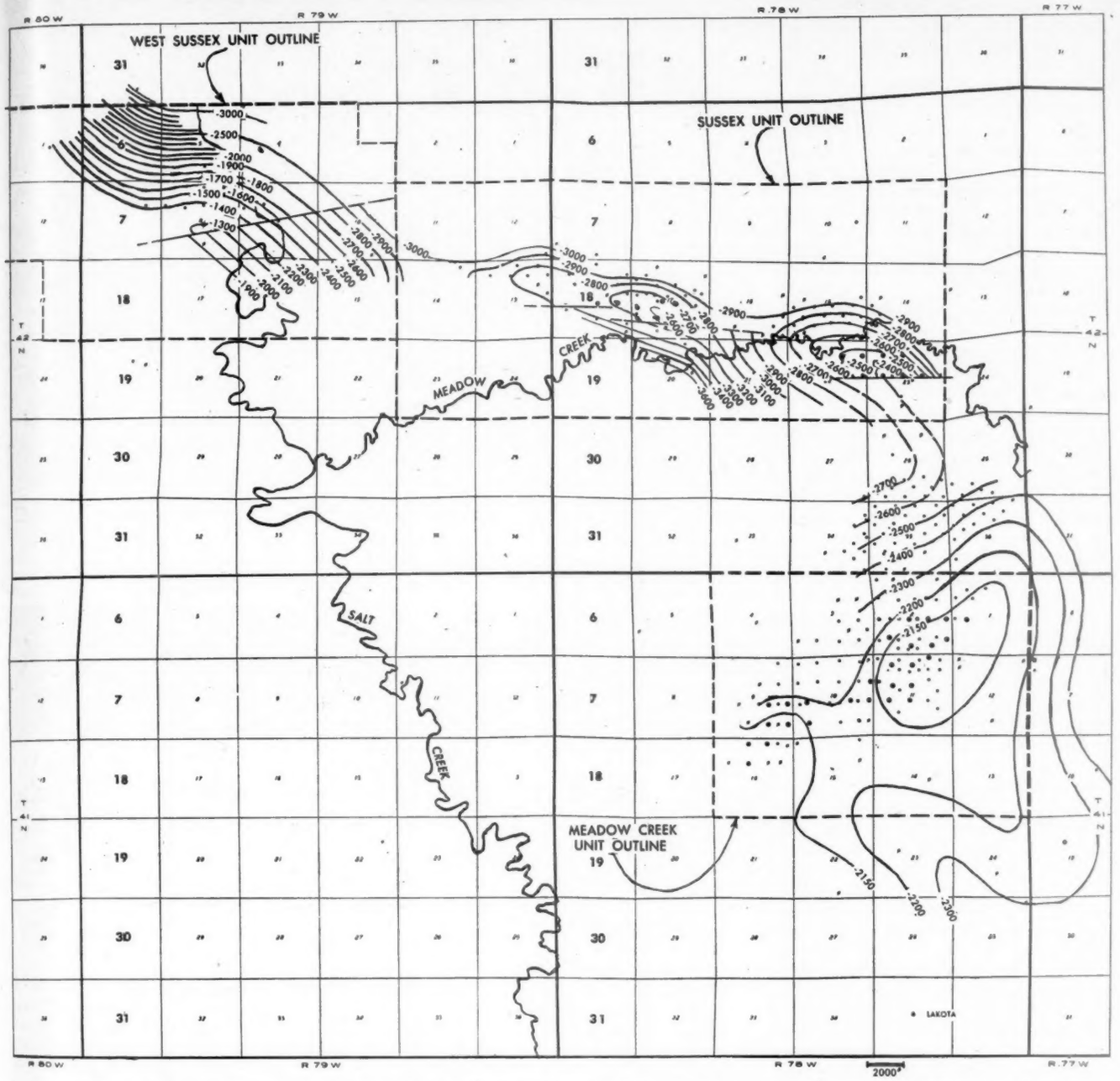


FIG. 2. Sussex, West Sussex and Meadow Creek areas, Johnson County, Wyoming. (Contoured on Lakota sand.) • Lakota wells.

test to the basal Cambrian in SE NE NW Section 11, Township 41 North, Range 78 West, penetrated a typical sedimentary section for the area. This well was drilled to a total depth of 10,726 ft before being plugged back for completion in the Tensleep sand for a potential of 240 bbl daily.

Sussex Sand. The Sussex sand produces in 5 pools in the Sussex and Meadow Creek Units and North Meadow Creek area. The sand is poorly developed in the West Sussex Unit. The net effective thickness of the Sussex is 30 ft. The cumulative production from 75 wells as of June 1, 1952, was 2,806,611 bbl.

Shannon Sand. The net thickness of the Shannon is 25 ft. It produces in 7 pools throughout the area. Seventy-eight wells produced 1,162,038 bbl to June 1, 1952.

First Wall Creek Sand. Two wells have been completed in the First Wall Creek for a cumulative of 19,899 bbl as of June 1, 1952. This sand, because of its lack of permeability, has been an unimportant reservoir so far.

Second Wall Creek Sand. Twelve wells have been completed in the Second Wall Creek in the Meadow Creek Unit. Recently, Second Wall Creek oil was tested in the west portion of the Sussex Unit, but the size of the reservoir has yet to be determined. The Second Wall Creek sand is shaled out in the Sussex "B" area, or east side of the unit. Net thickness of the sand is approximately 20 ft. Cumulative production to June 1, 1952, was 184,376 bbl.

Lakota Sand. The Lakota is productive in 5 pools throughout the area. Net thickness of the Lakota varies from 25 to 40 ft. As of June 1, 1952, the cumulative production from 42 wells was 2,209,728 bbl.

Tensleep Sand. The Tensleep may prove to be the most important reservoir in the Sussex and Meadow Creek areas. Due to lack of outlet, 8 wells have produced only 9519 bbl as of June 1, 1952. The Tensleep, with an average net thickness of 80 to 100 ft, is productive in 3 pools.

Additional zones that have tested oil, but have not been developed, are the Teapot and Parkman sands, 1300 and

1000 ft above the Sussex, respectively, the Sundance sand, and the Amsden(?) formation. No important shows have been observed below the Amsden(?).

Structure

General. Sussex and Meadow Creek fields are located on a broad structural terrace which lies on the northeast flank of the Salt Creek anticline (Fig. 1). The surface expression of this terrace is a pronounced broadening of the Lance outcrop to about 7 miles. Regional dip on the north end of the terrace is about 30 deg northeast into the Powder River Basin, while dips across the terrace are less than 10 deg northeast. Generally, subsurface drilling has outlined plunging anticlinal noses cut by transverse normal faults and, in places, reversal has been determined.

Meadow Creek Unit. A north plunging anticline lies in the Meadow Creek Unit and extends into the North Meadow Creek area (Fig. 2). At least one closure is present on the Lakota sand and this one lies in the east portion of the unitized area. The anticline is cut on the shallow sands by several small northeast striking faults, which apparently die out before reaching the Lakota.

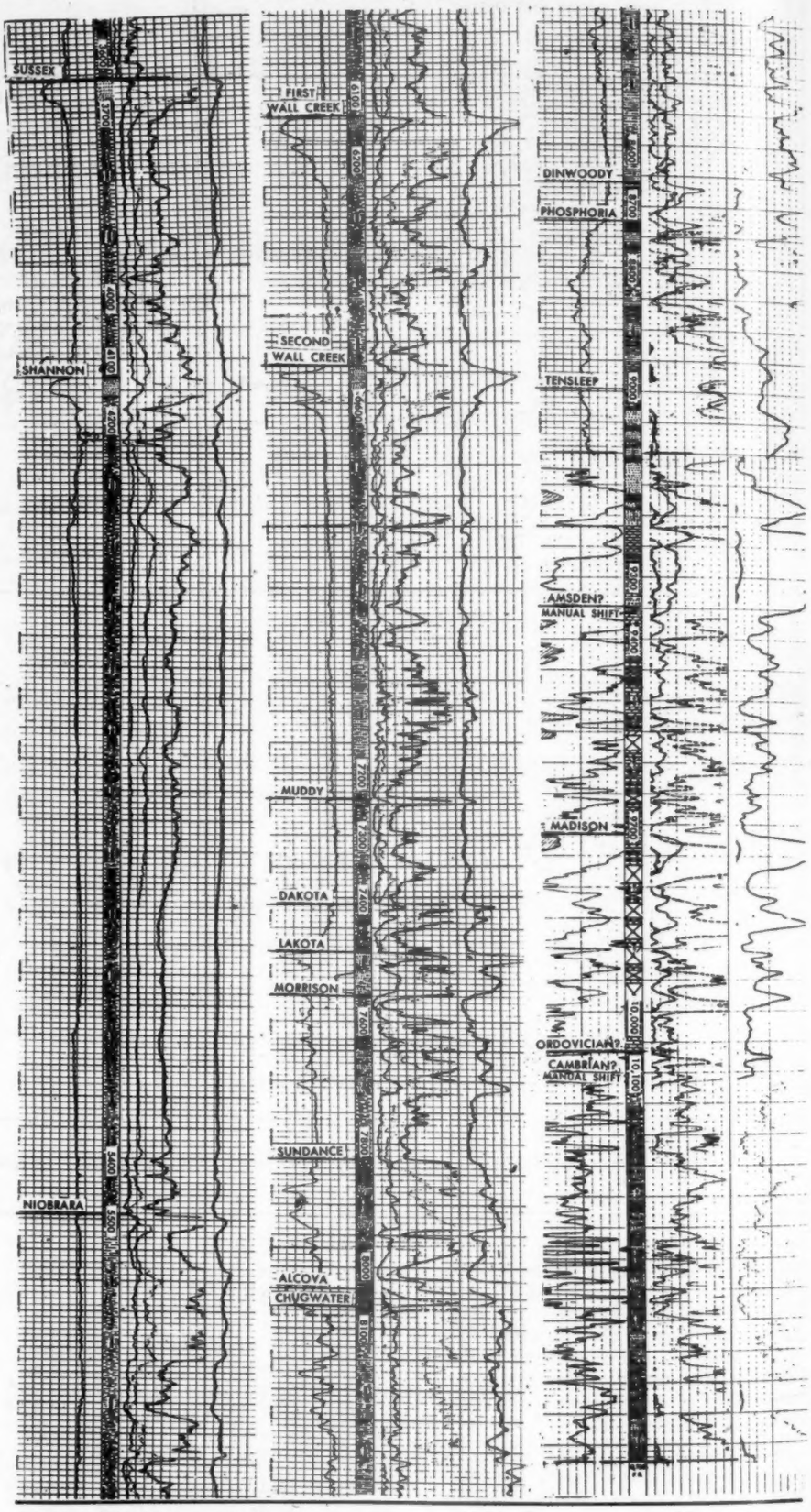
North Meadow Creek Area. The north plunge of the anticline mentioned above is cut on the shallow sands in the southern part of the North Meadow Creek area by a south-dipping transverse fault with about 150 ft of throw.

Sussex Unit. In the east portion of the Sussex Unit a northwest trending anticlinal nose is cut on the shallow sands by an east-west-trending south-dipping fault with 1000 ft of throw. This same fault appears to have 200 to 300 ft of throw on the Lakota horizon (Fig. 2). On the west side of the Sussex Unit another northwest-trending anticlinal nose has been cut at least down to the Lakota sand by two east-west trending south-dipping faults with 400 to 500 ft of throw. One of these faults offsets the Tensleep horizon.

West Sussex Unit. The structural picture in the West Sussex Unit is similar to that found in the Sussex Unit. In the West Sussex Unit a north-plunging nose has been cut down to the Lakota sand by a transverse fault with from 600 to 900 ft of throw.

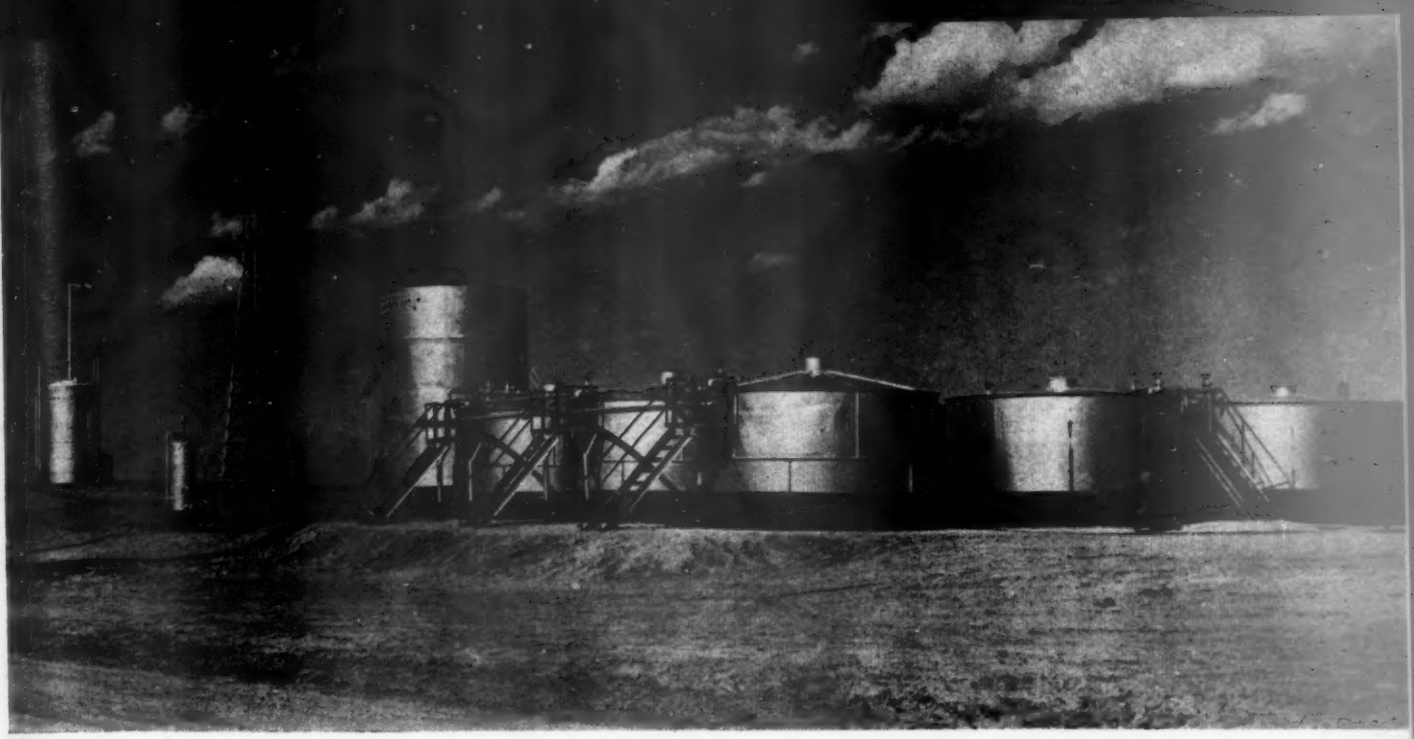
Factors Governing Accumulation. The oil accumulations in the shallow sands in the Sussex and Meadow Creek areas are trapped primarily by normal faults that offset the producing horizon. Reversal and lateral stratigraphic changes also control accumulations in the shallow sands of the Meadow Creek Unit. Oil pools in the Lakota sand in the Sussex and West Sussex Units are controlled by faulting. In the Meadow Creek Unit reversal again appears to be the important factor in effecting Lakota accumulations. The Lakota sand in the southwest portion of the Meadow Creek Unit becomes impermeable and, here, the accumulation may be due to a permeability trap. The Tensleep pool on the west side of the Sussex Unit is probably controlled by faulting. The two remaining Tensleep pools have not been developed sufficiently to determine the factors governing accumulation.

FIG. 3. Representative log of Sussex and Meadow Creek areas, Johnson County, Wyoming.



Acknowledgments

The writer wishes to express his appreciation to Continental Oil Company for permission to publish this article and to fellow employees for their assistance and criticisms. The writer also acknowledges the assistance of J. W. Strickland for tentative identification of some of the lower Paleozoic fossils. Additional study is at present underway in an attempt to confirm and further subdivide the nomenclature. * * *



The Ohio Oil Company's Elizabeth Lamb No. 2 in Lance Creek field with separator and storage tanks.

P 410.

Lance Creek Field Fills Big Role

Lance Creek field, discovered in 1918, demonstrated how good production practices pay off in carefully developed area

R. M. CHURCHWELL*

THE Powder River Basin is one of the largest intermountain basins in the Rocky Mountain Region. It extends from the Laramie Range and the Hartville Uplift in Wyoming on the south to the central part of Montana on the north, or a distance of over 200 miles, and is bounded on the west by the Big Horn Mountains of Wyoming and on the east by the Black Hills of South Dakota, a distance of over 100 miles. The basin contains over 26,000 sq miles of area.

Exploration in the Powder River Basin has been in progress since 1908, following the discovery of the fabulous Salt Creek field in that year. Most of the prominent surface structures on the periphery of the Powder River Basin were drilled in the following years resulting in major discoveries such as Big Muddy in 1916, Lance Creek in 1918, Mule Creek and East Lance Creek in 1919, Notches in 1923, and Cole Creek in 1938. Discoveries that occurred during and after the Second World War are little Buck Creek in 1944, Glenrock and South Glenrock in 1950, and of major importance on the basinward side of the Salt Creek field, the Taylor-Sussex and Meadow Creek fields in 1949 and 1950.

The fields mentioned above, plus numerous discoveries of lesser importance have outlined, to some extent, the productive areas of the Powder River Basin along its southern extremity and northward along each side for a considerable distance. No discoveries of any importance, however, have been found on the northwest, north, and northeast edges of the basin. The same applies for the center of the basin.

*Division Engineer, The Ohio Oil Company.

Lance Creek Field

The Powder River Basin has been an important oil-producing area since early in the history of the petroleum industry in Wyoming and in the Rocky Mountain Region. Lance Creek, which was discovered in 1918, will be discussed as an illustrative example of Powder River Basin production. This field has been second only to Salt Creek with regard to the amount of oil produced by a field within the basin; to date some 78,000,000 bbl. The field is especially interesting due to the fact that so many horizons were productive, namely 12; and, also, since high gravity sweet oil is produced from rock of Pennsylvanian age contrary to the heavy black sour oil usually encountered.

The Lance Creek field has also been of importance because it has been a large source of engineering and geologic data, which has facilitated the understanding of the typical Rocky Mountain type reservoirs. The field assumes further importance as being one of the very early unit operations in the Rocky Mountain Region. Sufficient history of orderly withdrawals and of pressure maintenance has been accumulated so that it is possible to evaluate the benefits derived through unit operations.

The Lance Creek structure lies south and west of the Black Hills and north of the Hartville Uplift, and about 20 miles north of the town of Lusk, Wyoming. The field comprises the west end of an anticlinal axis about 12 miles in length trending east and west.

Discovery — Cloverly Zones

The Lance Creek field was discovered in October, 1918, when The Ohio Oil Company completed a well on the east edge of the field, which produced 80 bbl

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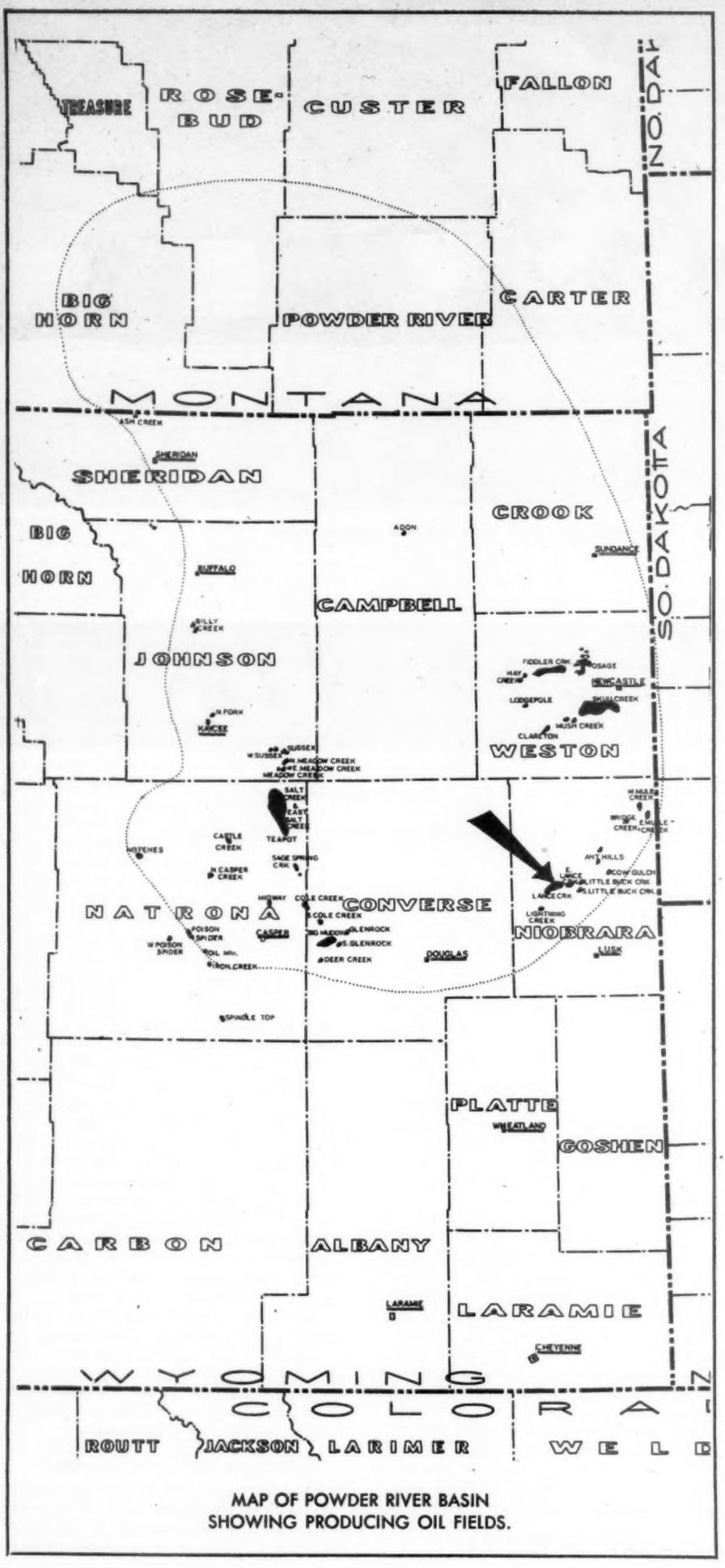
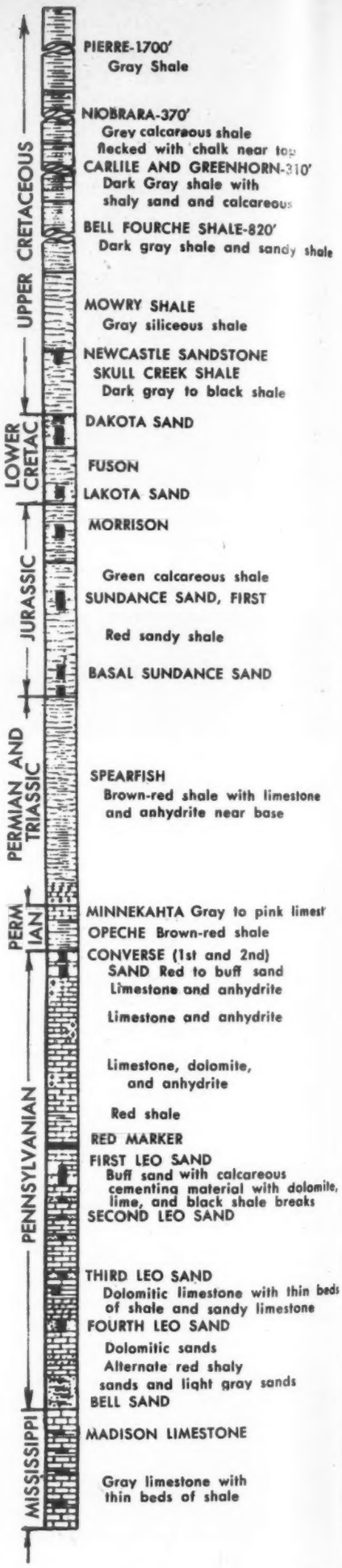


MAP OF POWDER RIVER BASIN
SHOWING PRODUCING OIL FIELDS.

Stratigraphic Section



PIERRE-1700'
Gray Shale

NIOBRARA-370'
Grey calcareous shale flecked with chalk near top

CARLILE AND GREENHORN-310'
Dark Gray shale with shaly sand and calcareous

BELL FOURCHE SHALE-820'
Dark gray shale and sandy shale

MOWRY SHALE
Gray siliceous shale

NEWCASTLE SANDSTONE
SKULL CREEK SHALE
Dark gray to black shale

DAKOTA SAND

FUSON

LAKOTA SAND

MORRISON

Green calcareous shale

SUNDANCE SAND, FIRST

Red sandy shale

BASAL SUNDANCE SAND

SPEARFISH
Brown-red shale with limestone and anhydrite near base

MINNEKAHTA Gray to pink limest

OPECHE Brown-red shale

CONVERSE (1st and 2nd) SAND Red to buff sand
Limestone and anhydrite

Limestone and anhydrite

Limestone, dolomite, and anhydrite

Red shale

RED MARKER

FIRST LEO SAND
Buff sand with calcareous cementing material with dolomite, lime, and black shale breaks

SECOND LEO SAND

THIRD LEO SAND
Dolomitic limestone with thin beds of shale and sandy limestone

FOURTH LEO SAND
Dolomitic sands
Alternate red shaly sands and light gray sands

BELL SAND

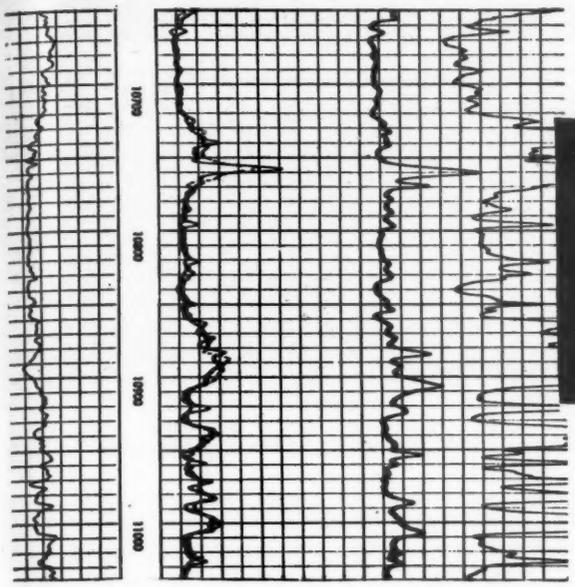
MADISON LIMESTONE

Gray limestone with thin beds of shale

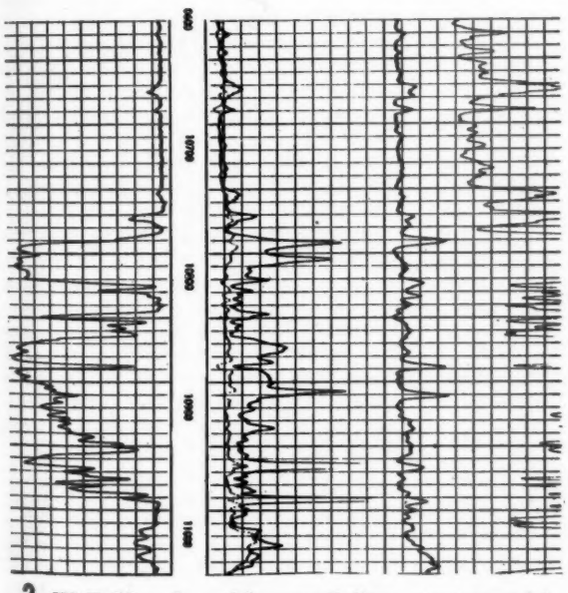
DEEP, HIGH-TEMPERATURE WELLS?

Drill with

DRISCOSE*



1. Section of Well No. 1, logged with a lime base, oil emulsion system. Log in this mud offers some interpretation and correlation problems.



2. Well No. 2, with paralleling strategraphic structure, was drilled with a Driscose base oil emulsion system. Observe the improved spontaneous potential curve on the left. Furthermore, no mechanical or gelation problems.

Low alkalinity, low solids, Driscose base, oil type emulsion muds provide accurate log interpretation —minimize gelation problems

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For practical, profitable advice on your particular mud problems—deep well or not—consult our experienced mud engineers.

Order Driscose from your regular mud dealer. Shipped in 50-pound, 6-ply, water resistant bags.

Portions of electric logs shown at left are further identified and discussed in the June, 1952 WORLD OIL article, "CMC Blended for Improved Resistivity."

*DRISCOSE *is a trademark for Sodium Carboxymethylcellulose*

DRILLING SPECIALTIES COMPANY

BARTLESVILLE, OKLAHOMA

Unit compressor plant at Lance Creek, Wyoming, with derricks of the field showing up in the background.

of oil daily from the Wall Creek sand (Upper Cretaceous) at a depth of 2689 ft and was later deepened to the Second Dakota at 3663 ft, from which it produced 1500 bbl per day of 38 API gravity oil. This discovery caused a drilling boom, but due to the disappointing results, the boom was over by 1921. By 1930 approximately 120 wells had been drilled to sands in the Dakota series. It is estimated that between 4½ and 5,000,000 bbl of oil and 45 to 50 billion cubic feet of gas was produced from these Cloverly sands of Lower Cretaceous age. The Muddy and Dakota sands produced the major portion of the oil, while the Lakota sand was the predominant gas producer. Between 1927 and 1928, the majority of the gas produced was burned in a carbon-black plant in the area. Although these sands have been virtually depleted for several years, it is interesting to note that three of the original oil wells to the Cloverly sands are still producing. The Dakota sand of the series has been used in recent years as a storage reservoir for residue gas.

Morrison Sand

Much later in the life of the field about 40 ft of productive oil sand was discovered in the middle of the Morrison formation of Jurassic age. A drillstem test made in 1944 in a well on the crest of the structure yielded oil at a rate of 45 bbl per hour and gas at a rate of 500,000 cu ft per day. This zone has not been developed, since the area is very small and wells to other formations can be recompleted for the depletion of this small reserve.

First Sundance Sand

The First Sundance sand of Jurassic age in the Lance Creek field was discovered by The Ohio Oil Company in 1930; however, this zone was of relatively minor importance.

The First Sundance sand was unitized in May, 1942, by the three operators, The Continental Oil Company, Argo Oil Corporation, and The Ohio Oil Company, and 485 acres were included within the participating areas. Ten wells were ultimately drilled to this formation and production from this sand through January 1, 1952, was over 1,500,000 bbl.

Basal Sundance Sand

In 1935, Ohio Oil discovered a substantial reserve of oil in the Basal Sundance sand of Jurassic age. The Agnes Rohlff No. 2 well came in for an initial production from the Basal Sundance of better than 2000 bbl per day of 47 API gravity oil. This discovery touched off a major boom resulting in the drilling of 75 additional wells. In January, 1938, the majority of the productive area of the Basal Sundance reservoir was unitized by the same three operators previously mentioned, and an initial participating area was established, which included about 1600 acres. The unit operators constructed a gas recycling plant in conjunction with a gasoline and LPG plant which was constructed and operated by Continental Oil. Residue gas is returned to the Basal Sundance sand reservoir under a joint pressure maintenance program.

Pressure Maintenance. Cumulative oil production had reached approximately 4,000,000 bbl at the time pressure maintenance was begun. Bottom hole pressures had declined quite rapidly during the first four years of operation in the field and the rapid decline indicated a limited water drive. After pressure maintenance was started, the pressures were maintained at or near 75 per cent of the original pressure for a period of 8 years. After the initial 8-year period, it was impossible to inject sufficient gas to maintain the pressure, and the reservoir pressure has steadily declined.

Present pressures are approximately 25 per cent of the original pressure.

Production from the Basal Sundance sand is presently being obtained from the structurally low wells, which in most instances are on the edge of the reservoir. As of January 1, 1952, Basal Sundance sand production had been almost 34,000,000 bbl, which to date represents a recovery of almost 50 per cent of the estimated oil in place. Of the 34,000,000 bbl, almost 24,000,000 bbl have been recovered from the unitized area. Present day production from the Basal Sundance sand in the field is about 2200 bbl per day.

Water Flooding. During the past few months, the unit operators have instituted a pilot water flood program along the south edge of the reservoir. The source of water for this project is from the deeper Leo sand wells in the same field. This water is fresh and relatively pure, and to the present time has required no filtering or chemical treatment prior to injection.

A closed system of water injection is being used with the water flowing directly from a free water knockout on a Leo sand well to a skimmer tank at the injection well, and to date the water has been injected by gravity. It is much too early to form any conclusions on the possible success of this pilot water flood program, other than the fact that the Basal Sundance sand will take water with no apparent difficulty.

Converse Sand

In May of 1936, 42 API gravity oil was discovered in the Converse sand of the Upper Minnelusa formation of the Pennsylvanian age. This reservoir was unitized in 1943, and the same 3 operating companies established a 285-acre participating area and 4 wells have been completed in this sand. To January of this year, this small producing area had produced almost 1,000,000 bbl of oil.

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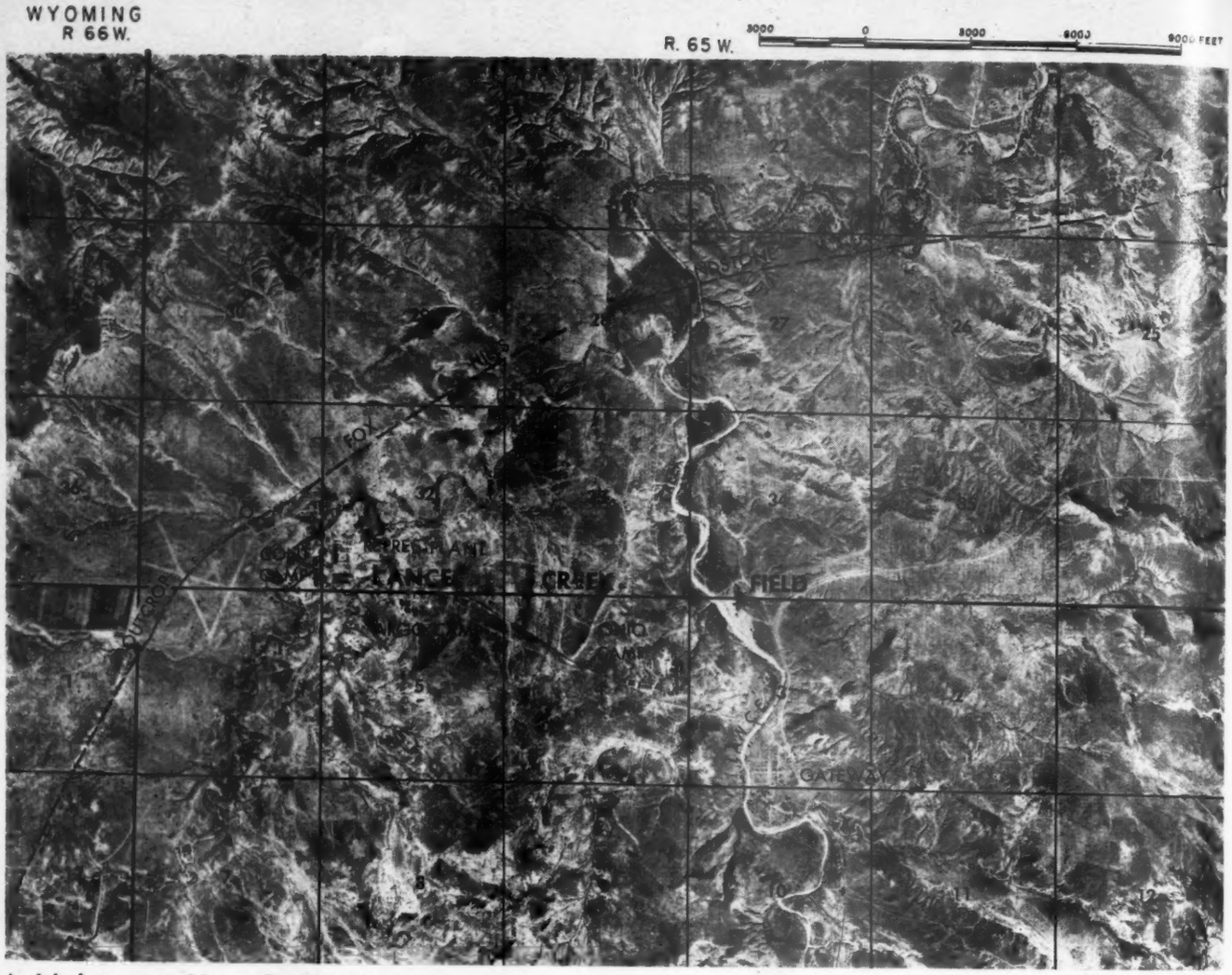
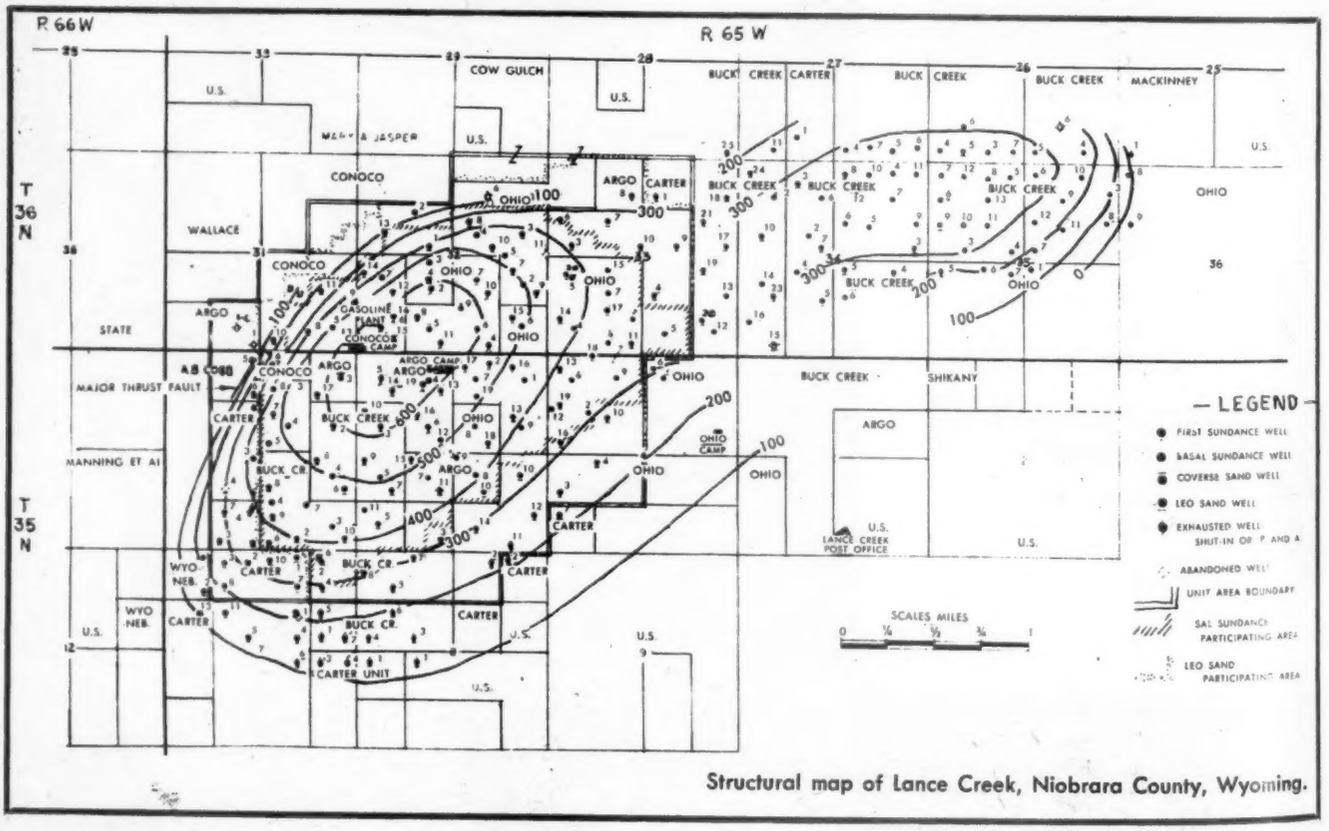


Aerial photo map of Lance Creek Field.

Courtesy Jack Ammann Photogrammetric Engineers.



Structural map of Lance Creek, Niobrara County, Wyoming.

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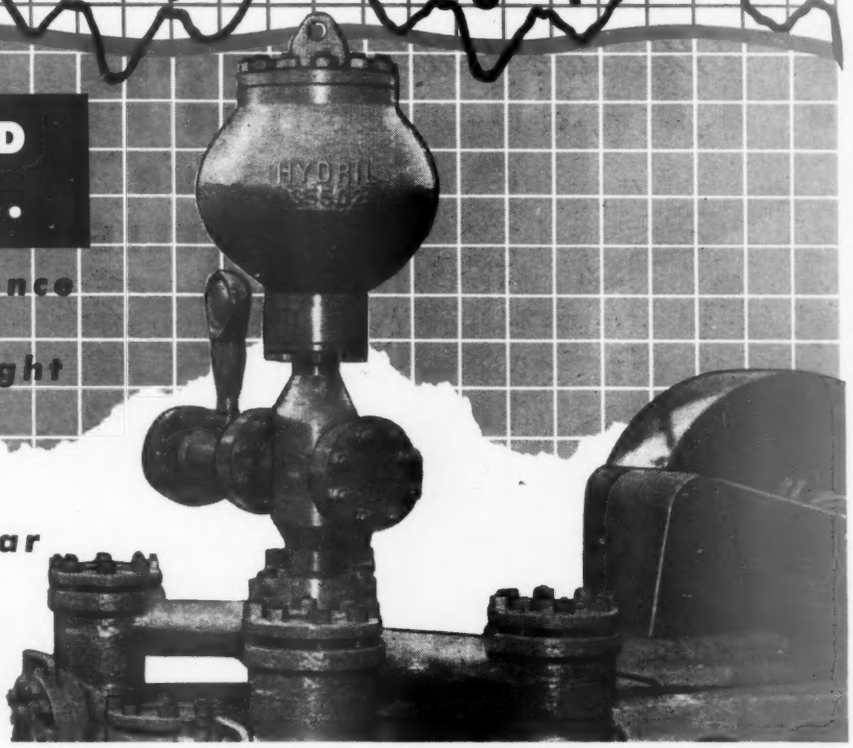

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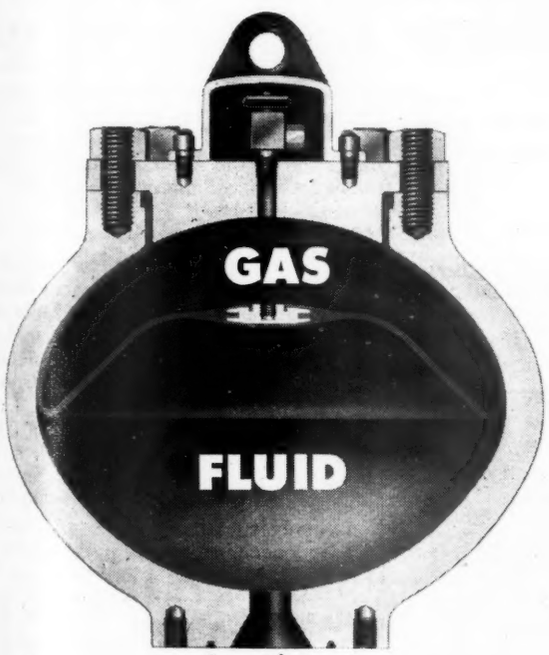

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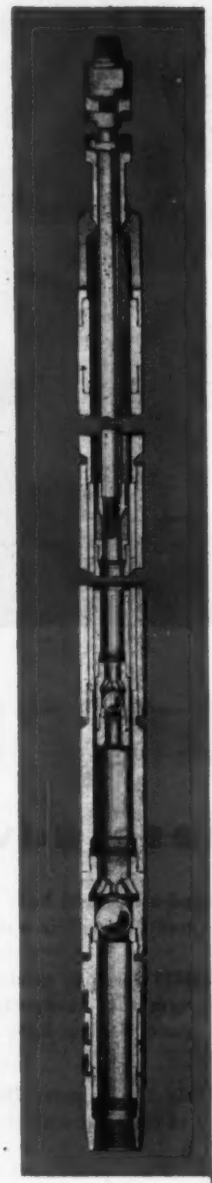

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Leo Sands

In June of 1937, The Ohio Oil Company again made a discovery of 47 API gravity oil in the First Leo sand of the Lower Minnelusa formation of the Pennsylvanian age. A third drilling boom resulted, and subsequent deeper drilling proved the existence of three additional zones in the Leo formation. During the same summer, the three operators unitized a 2332-acre Leo sand producing area, and to date some 145 wells have been drilled to the Leo sands. The porous or productive zones in the Leo occur irregularly through approximately 550 ft of sands, limes, dolomites, anhydrites, and shales. An effective water drive has maintained the pressure at about 80 per cent of the original value, and to January 1, 1949, the Leo sands had produced almost 36,000,000 bbl of oil. The contribution of nearly 22 billion cubic feet of gas from the Leo zones helped to make the pressure maintenance operation of the Basal Sundance sand a success.

In the fall of 1949, a high volume submerged centrifugal pump was installed in one of the Leo wells to determine if additional recovery could be obtained by the lowering of producing pressure to allow solution gas to expel some of the oil that was trapped in the low permeability zones. The installation of this pump proved very successful and the unit operators subsequently installed 6 additional pumps. Each pump is installed with a self-contained engine generating unit to supply the electrical power. During the past 3 years of high volume pump operations in the 7 unit wells, a total of approximately 900,000 bbl of oil and over 12,000,000 bbl of water had been recovered by these pumps. Leo wells within the unit area had produced about 26,000,000 bbl as of January 1, 1952.

Deep Tests

To the present date, there have been three deep tests drilled in the Lance Creek field. The original test was drilled on the apex of the structure; the other two were drilled on the flank. Each of these three tested the Madison limestone formation of the Mississippian age, but failed to find commercial production.

Summary

As of January 1, 1952, the Muddy, Dakota, Lakota, First Sundance, Basal Sundance, Converse, and Leo zones in the Lance Creek field have produced a total of almost 78,000,000 bbl of oil. Unitized portions of the First Sundance, Basal Sundance, Converse, and Leo zones had produced almost 53,000,000 bbl of oil to January 1, 1952. It is estimated that many millions of barrels of recoverable oil remain to be produced. Consequently, Lance Creek will continue in an important role in the modern history of the Powder River Basin, as it has done in the early history of the basin. The high per cent of recoveries experienced from some of the productive zones serves as a good example of the results to be obtained through good producing practices under unitization. ★

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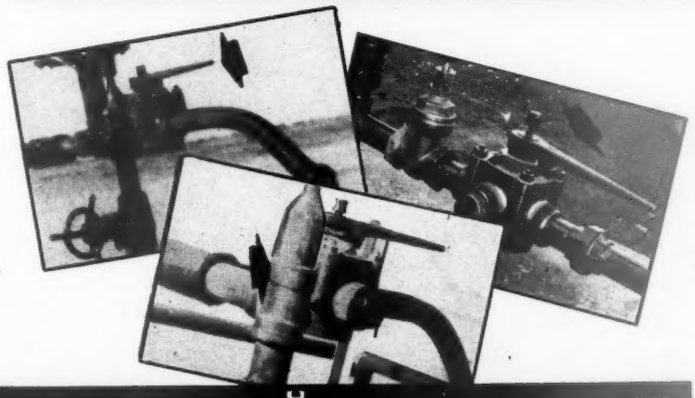

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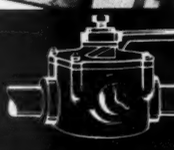

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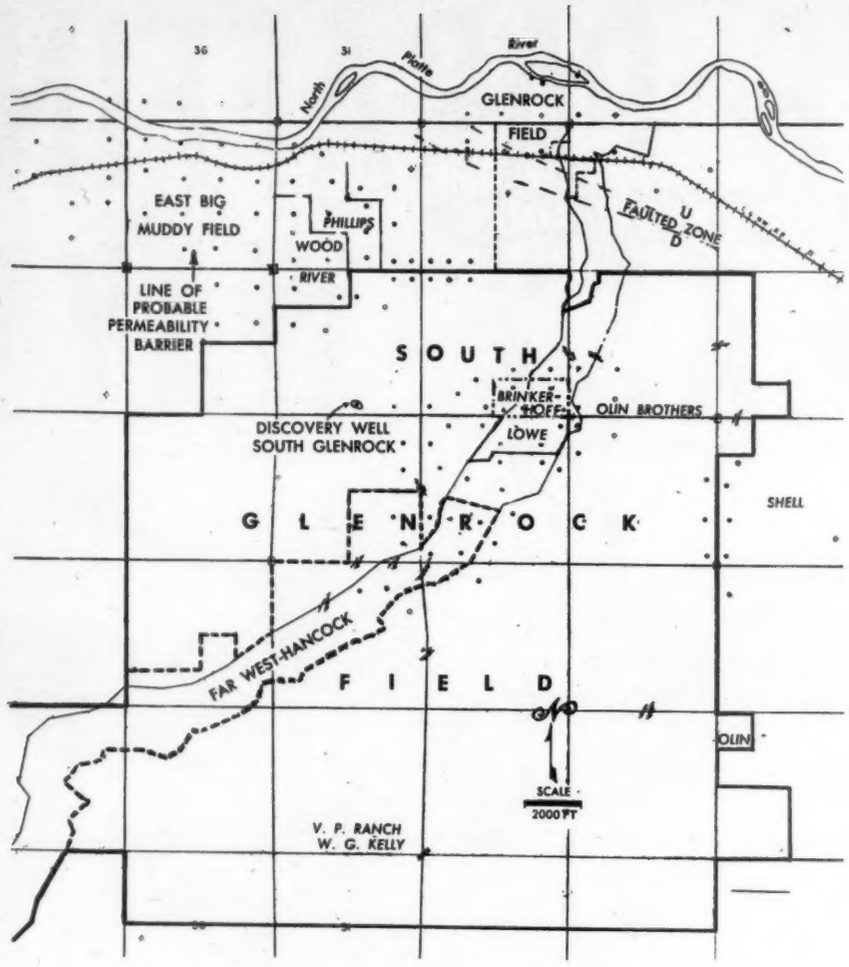

FIG. 1. Glenrock area near Casper, Wyoming.

What Sparks the Powder River Basin?

Powder River Basin contains 35,000 square miles with only important discoveries to date on outer rim

JACK MENNEER*

A VAST avenue for exploratory drilling still remains in the Powder River Basin although considerable oil field development has materialized over a period of 30 years. The recent oil discoveries in Ordovician formations at the southern part of the Williston Basin have served to increase the possibilities of similar production in the northern area of the Powder River Basin where the Ordovician is 400-500 ft thick. In time, no doubt, the bit will reveal the answer.

The Powder River Basin latitudinally extends across the eastern part of two states, from the Musselshell River in Montana to the River Platte in Wyoming, which is a distance of about 250 miles. To the east of the basin is the Black Hills mountain range in South Dakota and Wyoming, and to the west in Montana are the Big Horn Mountains, and in the southern extremity in Wyoming are the Hartville Uplift and the Laramie Range.

*Editor Drilling & Producing.

Hydrocarbon Accumulation

The elongated basin has an area of approximately 35,000 square miles and the strike is NNW-SSE. It is essentially a structural syncline type basin with Eocene formations in the central part, and on the outer rim relatively steep Mesozoic and Paleozoic exposures occur. The geological periods of the basin range from Cambrian to Tertiary, but the Silurian is presumably absent.

All important oil field discoveries have been in the outer rim of the basin. Some of these fields are Salt Creek, Cole Creek, Big Money, and Lance Creek, and of course there are several more. The four fields given as an example are structurally controlled and are domal anticlines.

Production is obtained from two different types of geological features.

1) Structural
2) Stratigraphical trap

The structural, which is usually a dome, is the more prolific producer and is characterized by multi-zones, the Salt Creek and Lance Creek fields have, as an example, 9 productive sections.

The stratigraphical trap is found largely in the lower Cretaceous sands, for example The Mush Creek and Fiddler Creek fields. A solitary producing horizon is the general rule and in any case not more than two will occur. These traps are lenticular depositions and have a general thickness of 10 ft, and occasionally 20 ft. The presence of stratigraphic trap reservoirs has brought about in recent years a new line of thinking concerning petroleum accumulation possibilities in the basin, because previously the search was mainly for dome structures.

Up to the present, the Mississippian or older limestone formations have not yielded any commercial oil. The Mississippian is about 1000 ft thick in the northern section of the basin and thins out in the south. The apparent absence of oil in this formation is unexplainable. Oil shows have been evidenced, but whether migration has occurred is problematic. On the other hand, erosion

The Powder River Basin covers 35,000 square miles in the states of Wyoming and Montana. Production has been obtained from the basin for many years and several major fields have been developed on the outer rim.

Exploratory drilling has many possibilities and particularly in the north where the neighboring Williston Basin has produced from Ordovician limestone formations.

The South Glenrock field, operated by the Far West Oil Company, is discussed. Production is obtained from sandstone reservoirs at approximately 5000 ft. The elimination of paraffinic deposition is successful.

A lime based mud is generally used in the basin when drilling below 6000 ft and an oil emulsion is considered necessary for a normal completion.

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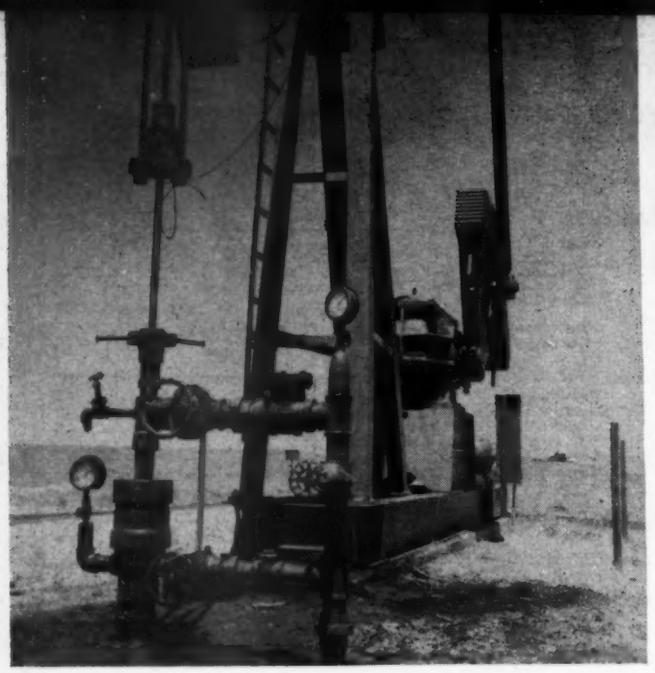
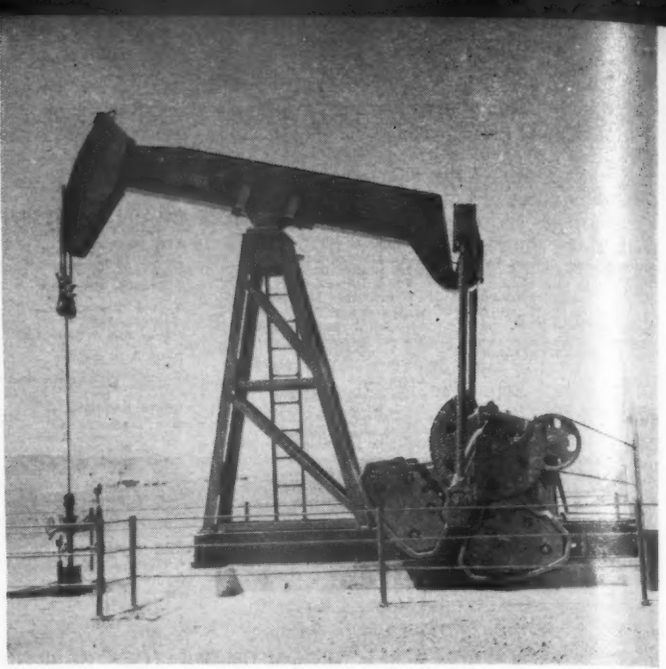


Discovery well South Glenrock field produces from about 5800 ft. Production is currently restricted to 75 bbl per day. Note the electrical power drive.



Well State 7 No. 6. Far West is the operator in the South Glenrock field. Producing from the Dakota sand at 6200 ft. The average gravity of the crude is 37 deg.

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PALEOCENE	FORT UNION	FORT UNION	FORT UNION	FORT UNION: Tongue Rv. / Lebo / Tullock		FERRIS	FERRIS	EVANSTON
UPPER CRETACEOUS	LANCE	LANCE	LANCE	LANCE	LANCE	MEDICINE BOW	LANCE	LANCE
	MEETEETSE	LEWIS	FOX HILLS / LEWIS	FOX HILLS	FOX HILLS	LEWIS	LEWIS	LEWIS
	MESAVERDE	MESAVERDE	MESAVERDE	PIERRE	Hygiene Ss. / PIERRE	MESAVERDE	MESAVERDE	ADAVILLE: ALMOND / ERICSON / ROCK SPRINGS / BLAIR
	CODY	CODY	Sussex Ss. / STEELE / Shannon Ss.			STEELE	STEELE	HILLIARD / BAXTER
			NIOBRARA	NIOBRARA	NIOBRARA	NIOBRARA	NIOBRARA	
			CARLILE	CARLILE	CARLILE	CARLILE	CARLILE	FRONTIER / BAXTER
	FRONTIER	FRONTIER	FRONTIER	GREENHORN	GREENHORN	FRONTIER	FRONTIER	
	MOWRY	MOWRY	MOWRY	GRANEROS: BELLE FOURCHE / MOWRY / NEWCASTLE / SKULL CREEK	GRANEROS	MOWRY	MOWRY	ASPEN
	THERMOPOLIS / Muddy Ss.	THERMOPOLIS / Muddy Ss.	THERMOPOLIS / Muddy Ss.		Muddy Ss.	THERMOPOLIS / Muddy Ss.	THERMOPOLIS / Muddy Ss.	BEAR RIVER
LOWER CRETACEOUS	CLOVERLY: DAKOTA (GREYBULL) / FUSON / LAKOTA	CLOVERLY: DAKOTA / FUSON / LAKOTA	CLOVERLY: DAKOTA / FUSON / LAKOTA	DAKOTA (FALL RIVER) / FUSON / LAKOTA	CLOVERLY: DAKOTA / FUSON / LAKOTA	CLOVERLY: DAKOTA / FUSON / LAKOTA	CLOVERLY: DAKOTA / FUSON / LAKOTA	DAKOTA / FUSON / LAKOTA
JURASSIC	MORRISON	MORRISON	MORRISON	MORRISON	MORRISON	MORRISON	MORRISON	BECKWITH OR GANNETT: MORRISON
	SUNDANCE	SUNDANCE	SUNDANCE	SUNDANCE	SUNDANCE	SUNDANCE	SUNDANCE	CURTIS (STUMP) / ENTRADA (PREUSS)
	GYPSUM SPRING	GYPSUM SPRING / NUGGET	GYPSUM SPRING	GYPSUM SPRING			NUGGET	TWIN CREEK OR CARMEL / NUGGET
TRIASSIC	CHUGWATER	CHUGWATER	CHUGWATER	SPEARFISH	CHUGWATER	JELM / CHUGWATER	JELM / CHUGWATER	CHINLE OR ANKAREH / THAYNES
	DINWOODY	DINWOODY					DINWOODY	MORRISON OR WOODSIDE / DINWOODY
PERMIAN	EMBAR: PHOSPHORIA	EMBAR: PHOSPHORIA	PHOSPHORIA	MINNEKAHTA / OPECHE	MINNEKAHTA / OPECHE	? FORELLE ? / SATANKA	PHOSPHORIA	PHOSPHORIA OR PARK CITY
PENNSYLVANIAN	TENSLEEP	TENSLEEP	TENSLEEP	MINNELUSA	HARTVILLE	CASPER / FOUNTAIN	TENSLEEP	WELLS OR: TENSLEEP OR WEBER / AMSDEN OR MORGAN
	AMSDEN	AMSDEN	AMSDEN				AMSDEN	
MISSISSIPPIAN	MADISON	MADISON	MADISON	MADISON (PAHASAPA)	MADISON (GUERNSEY)		MADISON	MADISON
DEVONIAN	THREEFORKS / JEFFERSON	DARBY			DEVONIAN UNDIVIDED			THREEFORKS / JEFFERSON
ORDOVICIAN	BIGHORN	BIGHORN	BIGHORN	BIGHORN				ORDOVICIAN UNDIFFERENTIATED
CAMBRIAN	GALLATIN / GROS VENTRE / FLATHEAD	GALLATIN / GROS VENTRE / FLATHEAD	DEADWOOD	DEADWOOD		DEADWOOD	CAMBRIAN UNDIFFERENTIATED	CAMBRIAN UNDIFFERENTIATED
PRE-CAMBRIAN	METAMORPHIC & IGNEOUS ROCKS	METAMORPHIC & IGNEOUS ROCKS	METAMORPHIC & IGNEOUS ROCKS	METAMORPHIC & IGNEOUS ROCKS	METAMORPHIC & IGNEOUS ROCKS	METAMORPHIC & IGNEOUS ROCKS	METAMORPHIC & IGNEOUS ROCKS	METAMORPHIC & IGNEOUS ROCKS

FIG. 2. WYOMING STRATIGRAPHIC NOMENCLATURE CHART.

Compiled by Wyoming Geological Association Nomenclature Committee, March, 1950.

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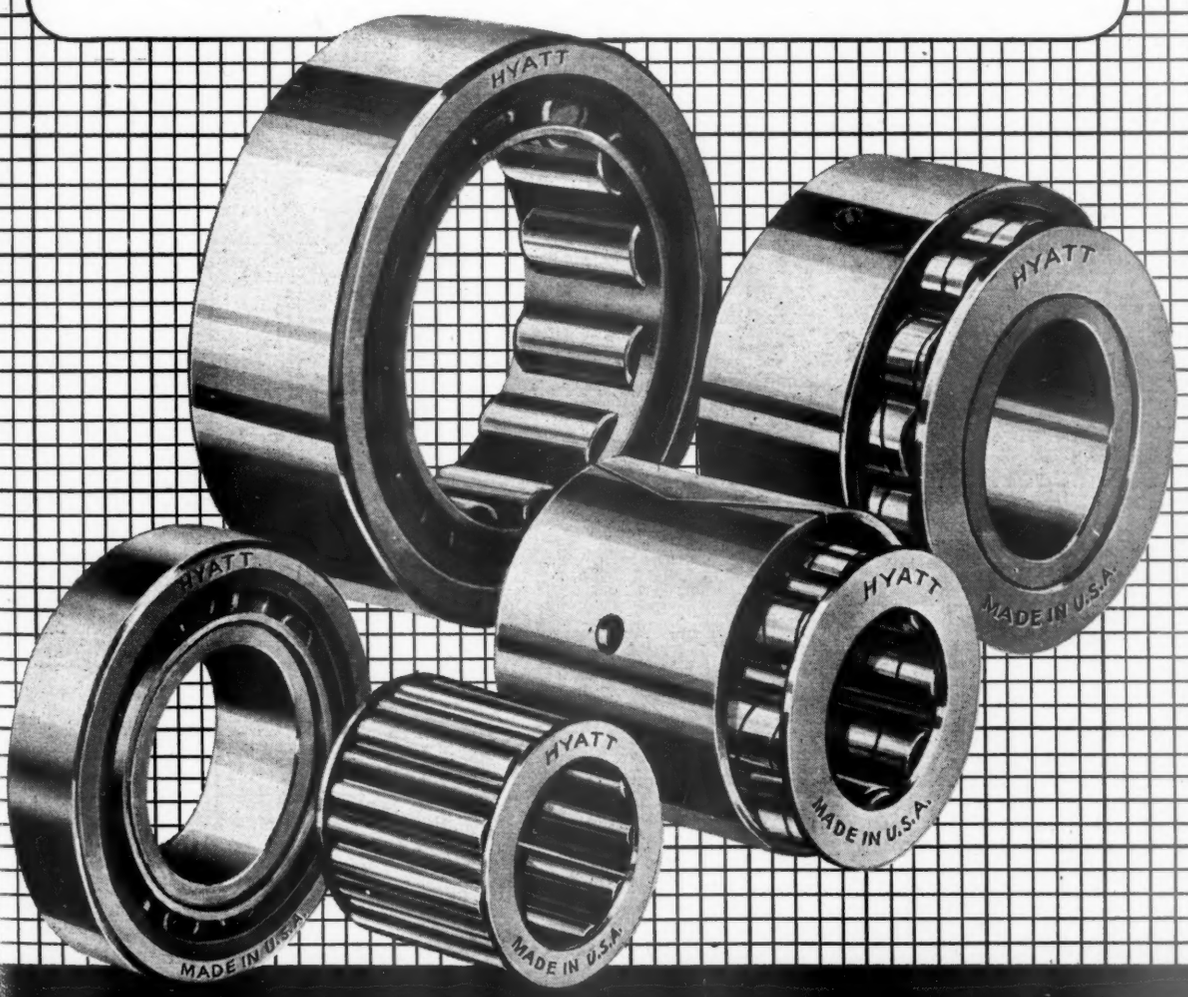


HYATT ROLLER BEARINGS

may have occurred and so denuded any oil that may have existed.

As mentioned earlier the ocurrence of oil in the 500-ft thick Ordovician to the north of the basin, has probabilities in view of the Williston's production.

The presently producing formations in the Powder River Basin are as follows: (1) Pennsylvanian, (2) Jurassic, (3) Lower Cretaceous, and (4) Upper Cretaceous.

The Pennsylvanian is an important producer but the major productive zones are contained in the Upper and Lower Cretaceous. In general, most of the oil is from above the 8000-ft mark.

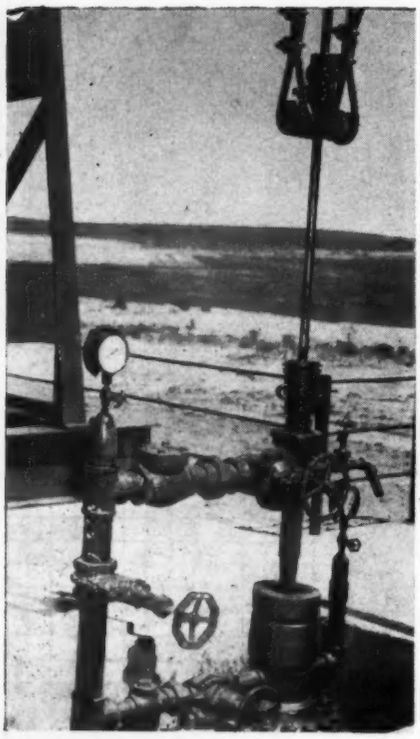
Two general types of oil are produced: (1) Pennsylvanian and, (2) Jurassic and Cretaceous.

The Pennsylvanian crude is of low gravity, 20 to 25 deg, with the exception of the Lance Creek field, which is higher. The Jurassic and Cretaceous oil is on an average 35 deg gravity. Some free gas is associated with the produced oil and particularly with the Cretaceous. The now depleted Billy Creek was a gas field, but this type does not predominate in the basin.

Exploration drilling is active in the basin and around ten seismic crews were operating during the month of July 1952. Seismic surveys are difficult at times due to severe topographical relief. Some 65 drilling rigs were actively engaged in the Powder River Basin during July 1952.

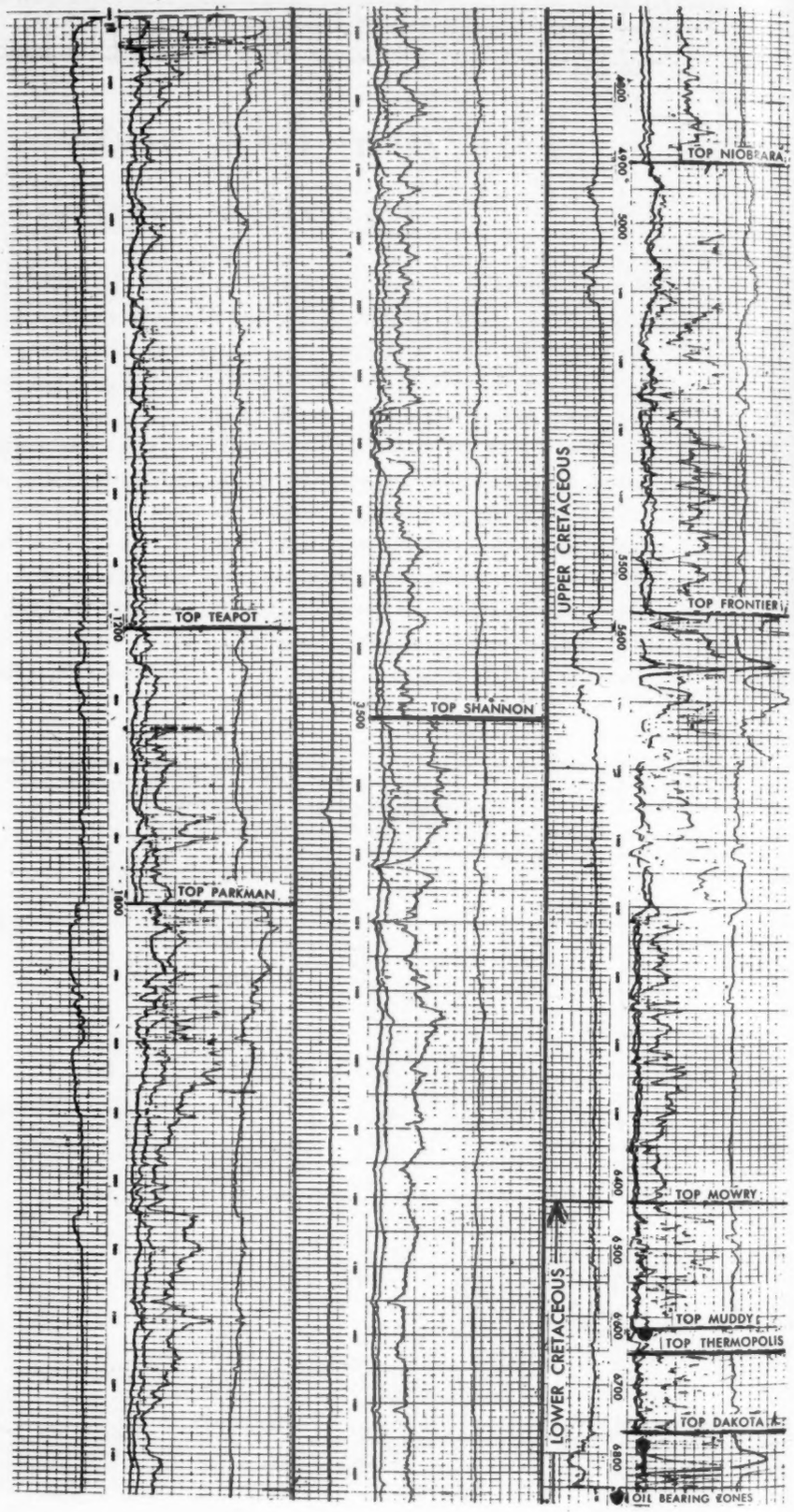
South Glenrock Field

Operations within the southern area of the basin merit discussion, as it is here the Hartville Uplift and the Laramie Range define a portion of the limits. In order to have a glimpse at the widely dispersed Powder River Basin activities a specific field, the South Glenrock, is chosen on acount of its generalized characteristics. (See Fig. 1).



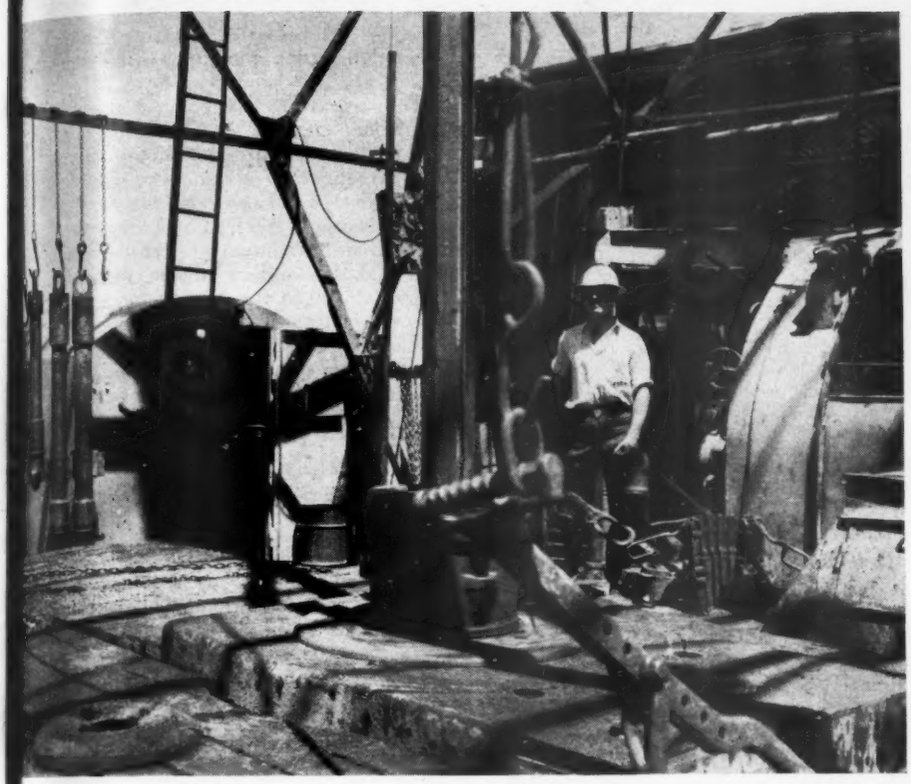
Well head arrangement on a typical South Glenrock well.

FIG. 3. Typical electric log in the Powder River Basin.



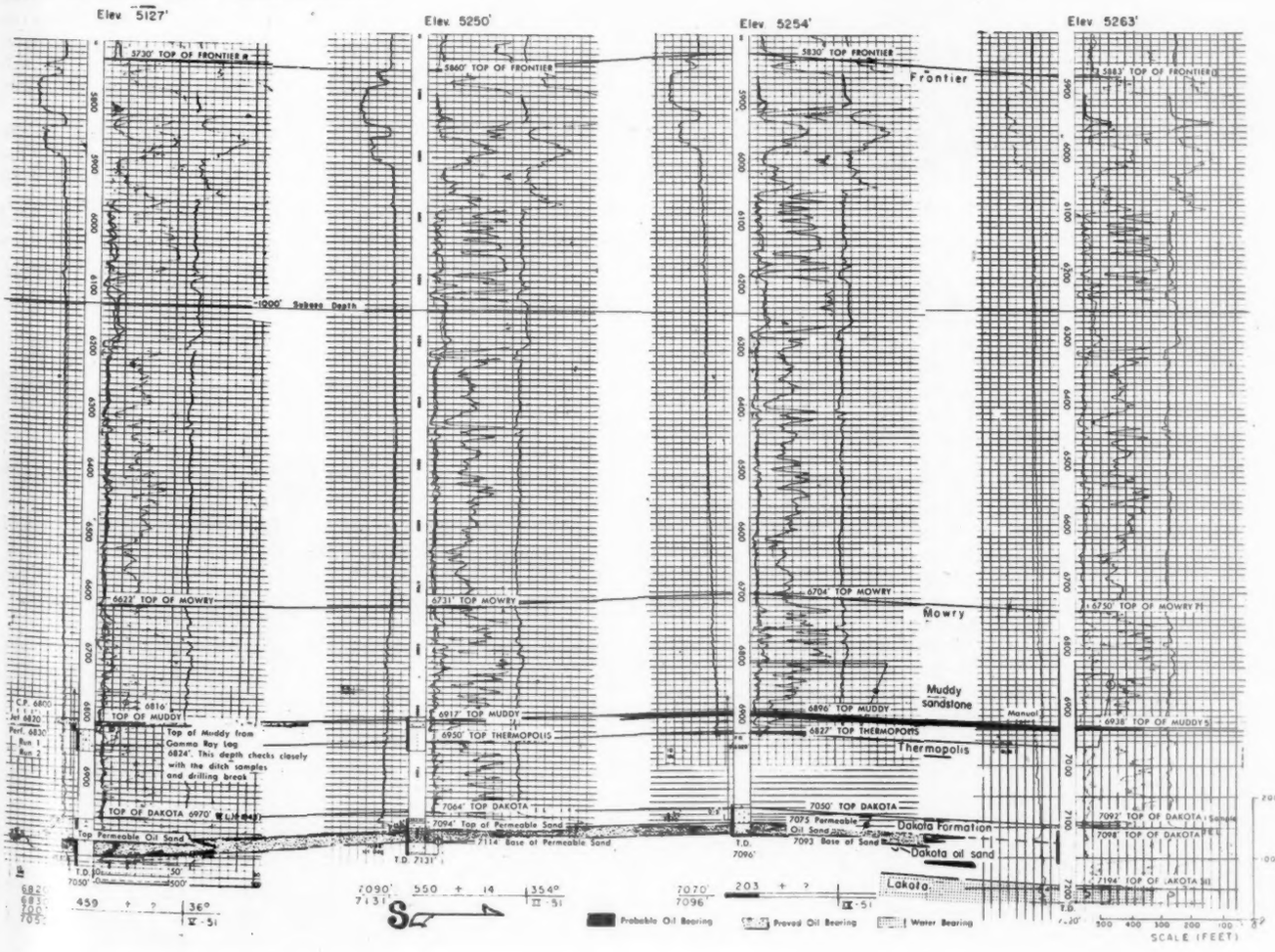
South Glenrock is situated 25 miles east of Casper and is principally a tri-ownership field, Far West, Hancock and Continental; the Far West Oil Company is the operator. To the west is the East Big Muddy field, and to the north is the Glenrock field. It is undecided whether the fields are common to each other and further development is necessary for final assessment.

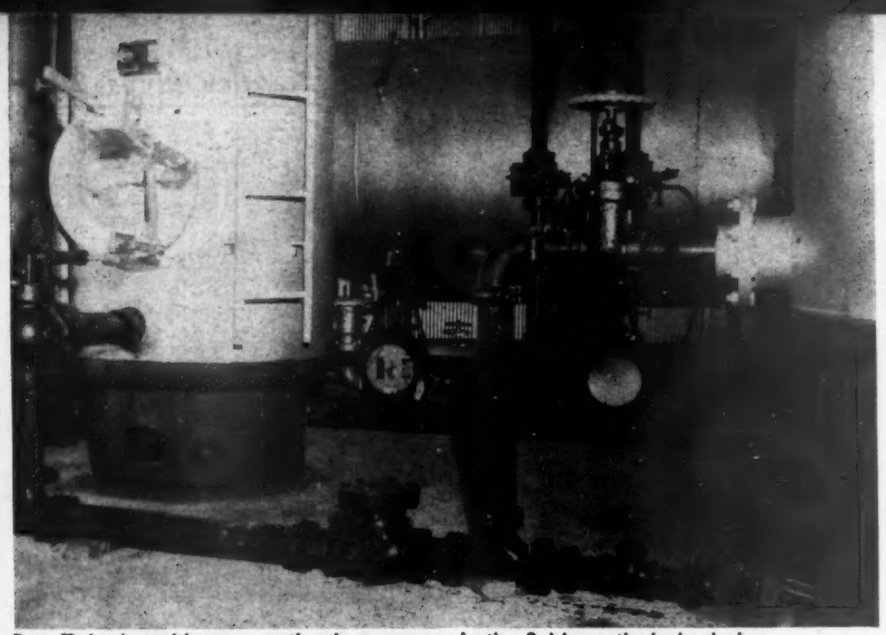
Production was obtained in the area in 1916 when the Big Muddy field, which is further west, was discovered and regional interest was revived when the South Glenrock State 7 No. 1 well came



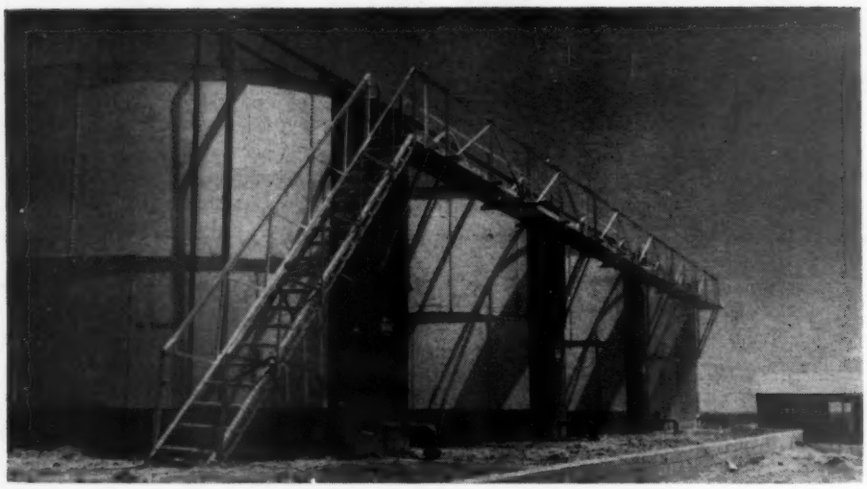
South Glenrock field, Wyoming. Well State 7 No. 12 drilling to 5900 ft for Dakota sand production. The drawworks is electrically operated and was converted from a steam power drive. Skidding the rig from location to location is practiced in the field — a maximum distance being half a mile. Prior to its present location the rig was skidded to 14 well sites. Drilling contractors True and Brown for the Far West Oil Company, Hancock, and Continental. P. J. Peterson is the driller.

FIG. 4. Cross section of South Glenrock.





Paraffinic deposition prevention is necessary in the field, particularly during the cold winter months. Produced crude is heated to 140 F.



A tank battery in the South Glenrock field. Some water production occurs.

in as a wildcat producer in June 1950. The reservoir is a south east plunging nose off the domal Big Muddy field. The 3 producing sand horizons (Cretaceous) are: (a) the First Muddy which occurs from 5800 to 6700 ft; (b) the Second Muddy which tops at from 5840 to 6740 ft, and (c) the Dakota which is found from 5980 to 6880 ft. The Dakota reservoir is continuous throughout the whole proved area, but the Muddy formations are more lenticular and the sand is absent in certain localities. To date 66 oil wells and one dry hole have been drilled in the field. This total of 67 wells is composed as follows: Far West 58, R. Lowe 4, and Brinkerhoff 5.

A probable permeability barrier exists between the South Glenrock and the Big Muddy field, and a faulted zone is present between the Glenrock and the South Glenrock, the latter is on the downthrown side. There is no gas cap and it is suspected that the oil-water contact is tilted with a generalized level of – 1800 ft. The three Shell wells drilled to the east may be the final producing limits in this particular direction on account of the oil-water contact, but the exact delineation remains an indefinite factor.

The reservoir has some water encroachment and a low GOR prevails. The mechanics of production are still in the investigation stage. The average porosity is 14 per cent and the permeability averages 49 millidarcies with a connate water content of 18.8 per cent. The Dakota sand is highly vertically fractured and in the Muddy formations this characteristic is less pronounced. The original BHP at 1000 ft datum was 2400 psi and some wells flowed initially, but the effect of withdrawal now requires Dakota wells to be completed on the pump.

Drilling

After setting the surface casing the wells were originally drilled to total depth, and casing was set and perforated for production. The present practice for a Dakota well is to set the surface casing at 300 ft and drill a 9-in. hole with a natural mud to a depth of from 4000 to 4500 ft. At this point the mud is converted to an oil emulsion with 70-sec viscosity, water loss 2 to 5 ccs and pH 8. Drilling is continued to the top of the Dakota sand, which is the 5½ in. casing depth. When the casing is cemented 4⅝ in. diamond coring is taken to total depth with a circulating fluid medium of crude oil. The well is completed open hole. A marked improvement was obtained in producing from the crude oil type completion, as prior to using this technique several months would elapse before the well eventually ridded itself of mud contamination.

The normal drilling pattern is 40-acre spacing and completions for the Muddy formations will be northeast 10 acres with the Dakota wells southwest.

Development of the Powder River Basin continues. Laying pump foundations in the South Glenrock field.

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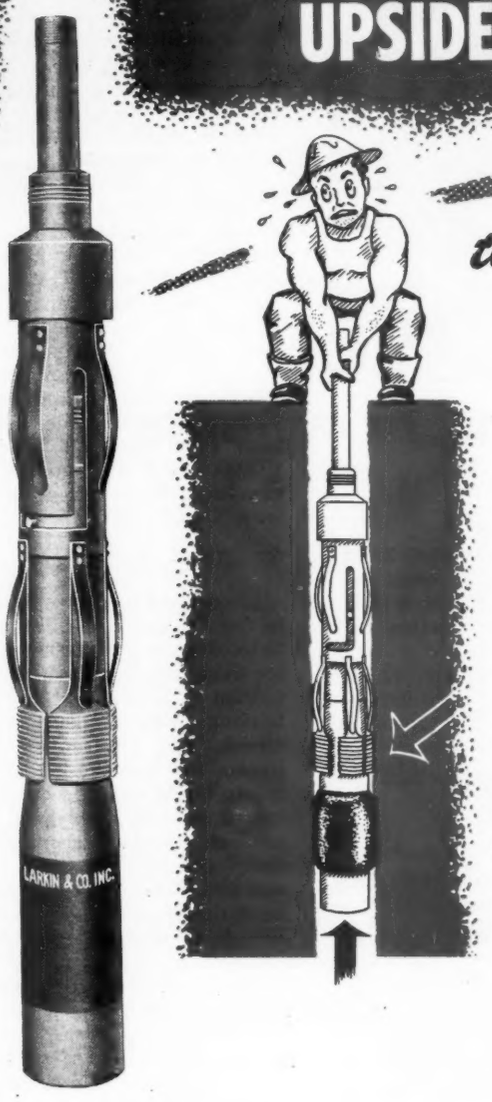

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Many of the wells in the South Glenrock are placed on pump immediately after the drilling operation. A special tubing machine is engaged.

Number of drill collars carried varies between 6 and 9 and the weight on the bit ranges from 6000 to 30,000 lb and medium rotational speeds are employed. Occasionally crooked hole drilling difficulties predominate in certain areas of the field and the problem is overcome by restricting both the rate of penetration and the weight on the bit. The average completion for a 6500-ft well is 28 days and some 23 roller type bits are used.

Production

A few Dakota locations were dually completed with the Muddy formations, but due to the short flowing life a reversion to single stage production was necessary.

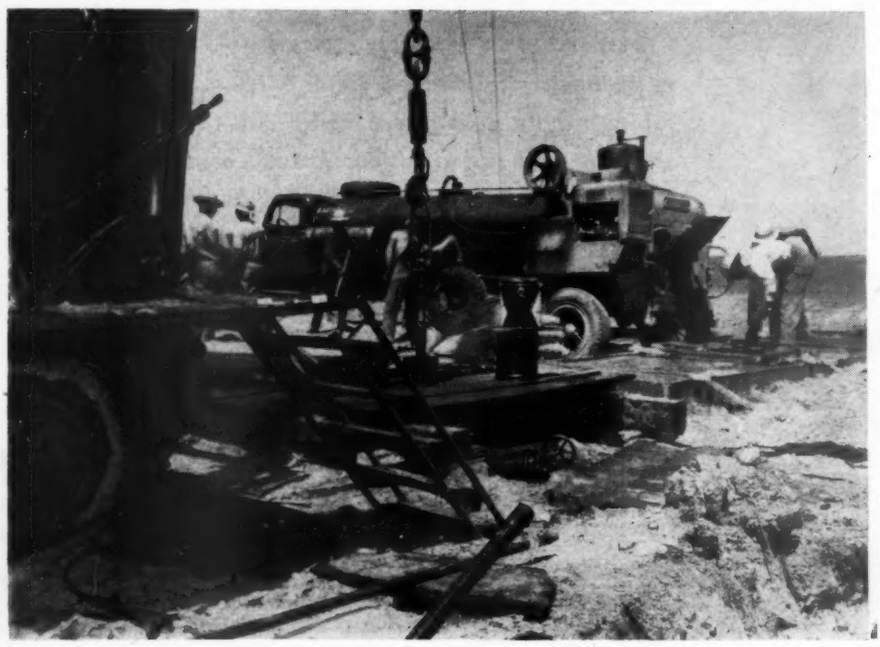
The oil is highly paraffinic, 37 deg gravity, and scrapers are often used on the sucker rods. Plastic flow lines are being laid and considerable success has been obtained with them. Special heater-treater surface equipment has been installed for the elimination of paraffinic deposition — a condition that can be accentuated by the cold Wyoming winters.

Flow lines are laid 5 ft deep and paraffinic plugs are run once a week. The production is limited to 75 bbl per day per well on account of the Powder River Basin marketable outlet restrictions. An average South Glenrock well would pump 220 bbl oil per day. A recent flowing producer from the Muddy formations came in at 1200 bbl per day.

Water production, brackish, is relatively small and is confined to the northeast flank, where, in all, nine wells make from 20 to 90 per cent water. The total cost for a South Glenrock well averages $90,000, that is to final completion, which includes a $2000 mud bill.

On the eastern edge of the South Glenrock field proper there are 3 producing wells operated by the Shell Oil Company. The pay interval is in the Dakota at 7094 to 7114 ft, (open hole) and an initial static bottom hole pressure of 2873 psi, and 2513 psi flowing, were recorded at a temperature of 148 F. These wells have up to a 40 per cent water cut. The drilling time for these 7100 ft wells averaged 40 days at a total cost per well of $125,000, or $95,000 exclusive surface equipment. Crooked hole troubles were encountered from 5700 to 6200 ft.

Flow lines have to be laid 5 ft deep in order to sustain production during the cold Wyoming winter. At the bottom center of the photo, and temporarily at 45 deg is a plastic flow line that will be laid to the wellhead. Plastic flow lines have been successful in the South Glenrock field for overcoming paraffin deposition.



Basin Generalities

Lime-based muds are used extensively in the Powder River Basin for drilling wells deeper than 6000 ft. The reason for using this type mud is for the prevention of gelling, and also to eliminate heaving shale difficulties that occur especially in the Frontier and Niobrara sections. (Cretaceous).

Gyp-based mud is sometimes used for combatting the anhydrite zones. Oil emulsion is used considerably in well completion drilling, particularly where mudding-off tendencies occur. Mud costs for the basin are as follows: Down to 3000 ft, negligible, 50 cents per foot to 5000 ft, approximately $1.50 per foot for 10,000 ft, and below this depth it is difficult to quote for variables may enter into the drilling operations when seeking any deeply seated oil.

Oil production from the basin supplies the Mid-West area and the completion of the 140,000 bbl per day Platte pipe line will partially reduce the basin's restrictive production policy.

The Powder River Basin has yielded oil for many years and the present trend is that production can be materially increased, which is emphasized by the fact that shut-in wells will be a necessity even after the new pipe line is opened. Moreover, the northern part of the basin is an area that may have successful oil development.

The spark that touched off oil activity in the basin 30 years ago has never been extinguished.

Selected Reference. Guide book published by the Wyoming Geological Association, "Fourth Annual Field Conference in the Powder River Basin. 1949."

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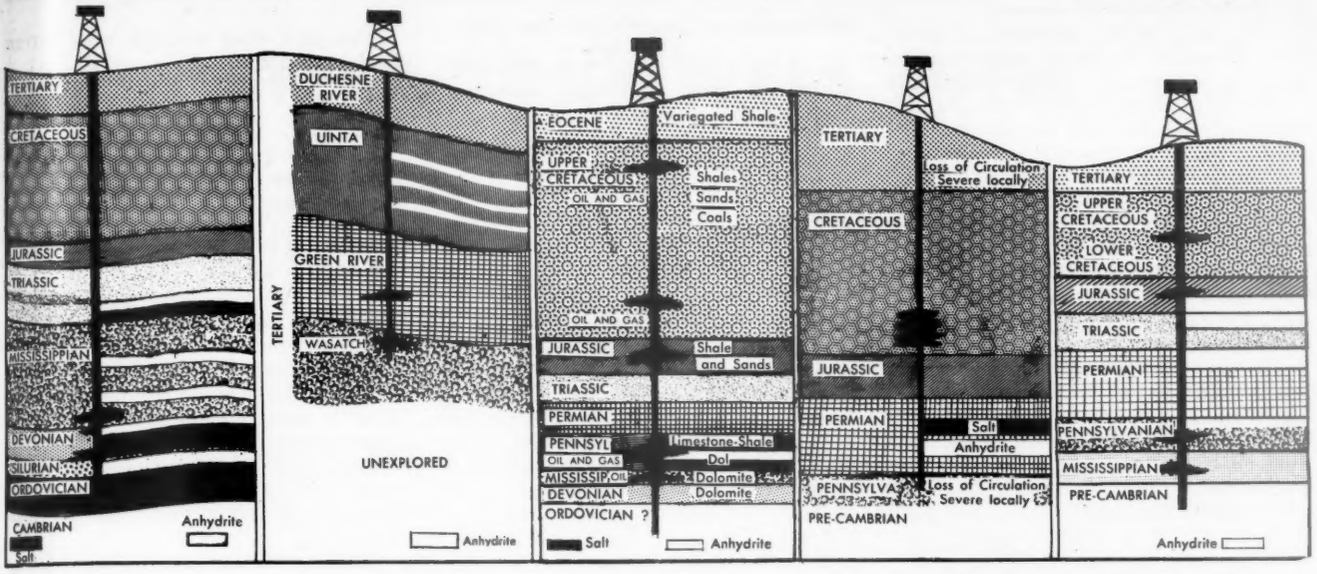

Mud Problems in the Powder River Basin

How familiar problems of lost circulation, well completion, and deep drilling are licked in various sections of the Basin.

B. J. STOVALL

THE major portion of the Powder River Basin is in eastern Wyoming with smaller portions extending into the southwestern corner of South Dakota and southeastern Montana. It is approximately 300 miles long on its North-South axis and 200 miles wide.

Structurally, the Powder River Basin is a broad syncline. Some marginal zones of relatively steep folding and faulting are present. About one-third of the sedimentary section is made up of late Cretaceous and Eocene non-marine deposits. Oil is found throughout the basin in formations ranging in age from Mississippian to Oligocene.

Most of the wells drilled in the eastern part of the basin do not present serious mud problems. The wells are drilled with clear water and native mud to the top of the Newcastle sand after setting about 200 ft of surface pipe. Large amounts of water are required because of the mud-making properties of the upper shale sections and penetration rates are rapid.

Most of the difficulty in this area is connected with well completion. Caving shale, which may bridge in the hole or accumulate on bottom, is usually encountered while attempting a drillstem test or an electric log. Much completion time may be saved by raising mud viscosities and lowering the filter loss at about 200 ft above the anticipated productive sand depth.

In the western part of the basin the wells are deeper and drilling problems more serious. As in the eastern part most of the production is from sands of Cretaceous age including the Sussex, Shannon, Frontier, Muddy, Dakota, and Lakota members. The Dakota sand, the most prominent producing formation, will vary in depth from 3000 ft to 9500 ft. It is usually a low pressure zone and minimum mud weights should be maintained. Surface casing is set at a depth of 300 to 700 ft with little difficulty, although loss of circulation may be encountered locally in coal beds.

Below the surface pipe a fresh water native mud is used for drilling the upper shale section to the top of the Niobrara section. The mud pits should be jetted and cleaned at frequent intervals. Large amounts of dilution water are required to overcome the build-up of native shale solids in the mud. Small quantities of bentonite are added to produce the mud viscosities required for removal of cuttings and cavings from the hole. A mud-treating program is begun in the Niobrara formation to overcome the tight hole conditions, which would otherwise develop in this chalkey limestone. Most of the adverse hole conditions can be overcome with the addition to the mud of bentonite and chemicals which control viscosity and gel strengths and improve the filtration properties. Various ratios of caustic soda mixed with the organic type thinners produce the desired mud properties. Phosphates

The Author

B. J. Stovall attended Texas Technological College in Lubbock. During the summer vacation months he roughnecked in oil fields in the Texas Gulf Coastal area. He joined the well logging department of Baroid Sales Division in 1945. From 1945 to 1948 his well logging activities took him from Mississippi to California. In 1948 he transferred to the drilling mud department as a service engineer and since that time has serviced drilling wells throughout the Rocky Mountain region. He is now stationed at Casper, Wyoming, from which point he services wells drilling in the Powder River Basin.

EXCLUSIVE

are also used for this purpose but to a lesser degree. In some areas where make-up waters are heavily contaminated with calcium sulfate the mud is chemically treated with barium carbonate for complete removal by precipitation of the flocculating calcium and sulfate ions.

Pretreatment with lost circulation materials will prevent loss of circulation while drilling through the Frontier section below the Niobrara. These materials are removed from the mud after drilling this section. Bentonite is added to the system to produce the necessary increased mud viscosity for deeper drilling in amounts determined by hole conditions. Low-pH-oil-emulsion muds are used successfully to complete wells in the Muddy (Newcastle) formation. The low filtration properties of the emulsion type mud favor its use for completing wells in this shaly oil producing sand. The typical properties of a 15 per cent by volume oil emulsion mud before and after conversion are:

	Before emulsion	15% oil emulsion
Weight, lb/gal	9.8	9.5
Viscosity, Sec. API Funnel	65	60
Initial Gel, grams, API	0	0
10 Minute Gel, grams, API	10	15
Filter Loss, cc, API	9.5	3.5
pH, Indicator	8.5	9

When drilling below the Cretaceous formation to the top of the Mississippian a series of anhydrite and gypsum deposits are encountered. This evaporite may exist as stringers or in massive form. Several types of drilling muds are used to drill these sections but the three most widely used and accepted are: High - pH - lime - starch, gypsum, and chemically treated bentonitc mud. The latter mud requires the use of barium-carbonate for complete removal by precipitation of the flocculating calcium and sulphate ions. The properties of an anhydrite contaminated bentonite mud before and after treating with barium carbonate are:

	Contaminated mud	Anhydrox treated mud
Weight, lb/gal	10	10
Viscosity, sec, API Funnel	80	60
Initial gel, grams, API	10	0
10 minute gel, grams, API	70	20
Filter loss, cc, API	38	12
pH, Indicator	9	9

The use of a high-pH-lime or gypsum mud is considered a more economical approach in areas where anhydrite is encountered in quantities requiring more than approximately 100 sacks (100 lb each) of barium carbonate for treatment.

Existing base muds are converted to high-pH-lime-starch muds before drilling into anhydrite. Prior to adding hydrated lime the system is diluted with as much as 50 per cent water. The pH is increased to about 12.0 by additions of caustic soda and organic type thinners. Modified starch is the filter loss control agent. It is added in sufficient quantity to reduce the filter loss to the desired values and is preserved by the high-pH of the mud. Mud properties are not adversely affected by drilling anhydrite when a high-pH-lime-starch mud is used. The typical properties of the lime base mud are:

Weight, lb/gal	10
Viscosity, sec, API Funnel	55 to 65
Initial gel, grams, API	0
10 minute gel, grams, API	15
Filter loss, cc, API	5
pH, indicator	12.5

Gypsum muds were recently introduced into this area for the purpose of drilling massive anhydrite sections. They are water base muds that have been saturated with gypsum by a controlled pretreatment. Subsequent contamination by formation anhydrite will cause no further increase in viscosity and gel strengths. As with a high-pH-lime mud, a modified starch is used for controlling the filter loss. A chemical preservative prevents fermentation of the starch. Better hole conditions are experienced and no trouble is encountered while making trips or during coring and testing operations with this type mud. The general properties of a gypsum mud on a wildcat well in Johnson County, Wyoming, are:

Weight, lb/gal	10
Viscosity, sec, API Funnel	55
Initial gel, grams, API	30
10-minute gel, grams, API	50
Filter loss, cc, API	8.4
pH, indicator	7
Preservative, lb/bbl	.3

Most of the drilling has been in the southern portion of the Powder River Basin. As development continues and wildcatting spreads throughout the basin, drilling mud programs and practices are continuously augmented. These will meet any problems encountered in new or deeper drilling. * * *

Rig making hole in Meadow Creek field.

Photo by C. W. Flood.

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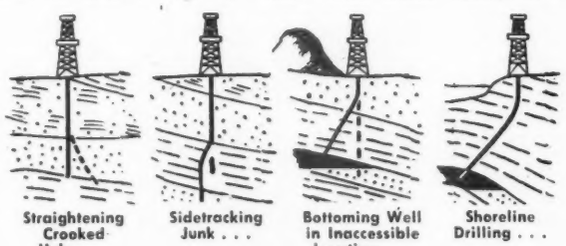

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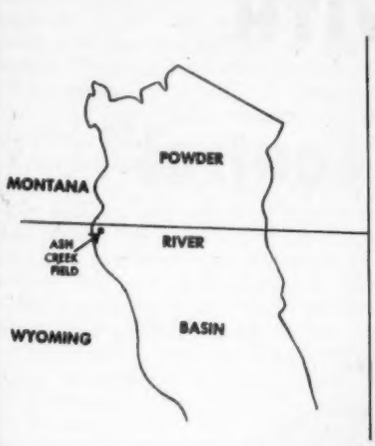

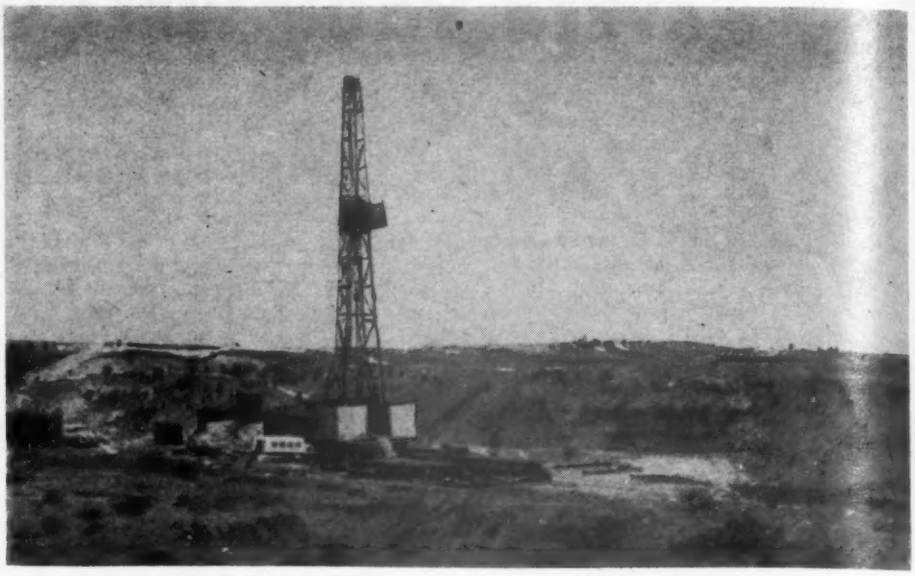

In May this year J. Ray McDermott and Company brought in a new field in the Powder River Basin up near the Wyoming-Montana line. This is Elsie Barry No. 1, discovery well, which had an initial production of 250 bbl a day.

Ash Creek Discovery Is Newest and Farthest North Field in Great Powder River Basin

W. E. WEST

EXCLUSIVE

ASH CREEK field, as presently developed, is in Sections 23-24, T 58 N, R 85 W, Sheridan County, Wyoming, and is the newest and northernmost oil discovery in the Powder River Basin.

Oil is found in the lower Shannon sand (Cretaceous age) from a fault type structure at an average depth of 4400 ft. The sand has an average thickness of 20 ft.

The Shannon sand is fairly soft, composed of medium to large, subangular, clear quartz grains, and is slightly glauconitic and carbonaceous. The sand's producing interval has an average permeability of 200 millidarcies per foot and an average porosity of 20 per cent.

The discovery well, Barry No. 1, was drilled by J. Ray McDermott and Company and was completed May 19, 1952 with an initial oil production rate of 200 bbl per day.

The second well, J. Ray McDermott and Company's and Shell Oil Company's Trusler No. 1, was completed June 28, 1952 with an initial production rate of 250 bbl per day.

The Author

W. E. West was graduated from the University of Oklahoma in January, 1950 with a BS degree in Geology. After graduation he was employed by the Halliburton Oil Well Cementing Company, and later by Core Laboratories, Inc., in the Rocky Mountain area. In September of 1951 he joined the geological department of J. Ray McDermott and Company, Inc., in Denver.

The gravity of the oil is 34 API, is black in color, is of intermediate base and has a pour point of 55 F. The oil is undersaturated and has a gas-oil ratio of less than 50 cu ft per barrel.

Drilling presents no unusual difficulties with wells requiring an average of 25 days for drilling and completion.

For completion 5½-in. OD casing is cemented through the sand with the pay interval subsequently perforated. Rod type pumping equipment is installed immediately following completion.

Fuel gas to operate pumping unit engines and other production facilities is obtained from a shallow gas well situated approximately one-half mile from the field.

The oil is presently being trucked to the pipe line at Midwest, Wyoming, a distance of approximately 100 miles. *

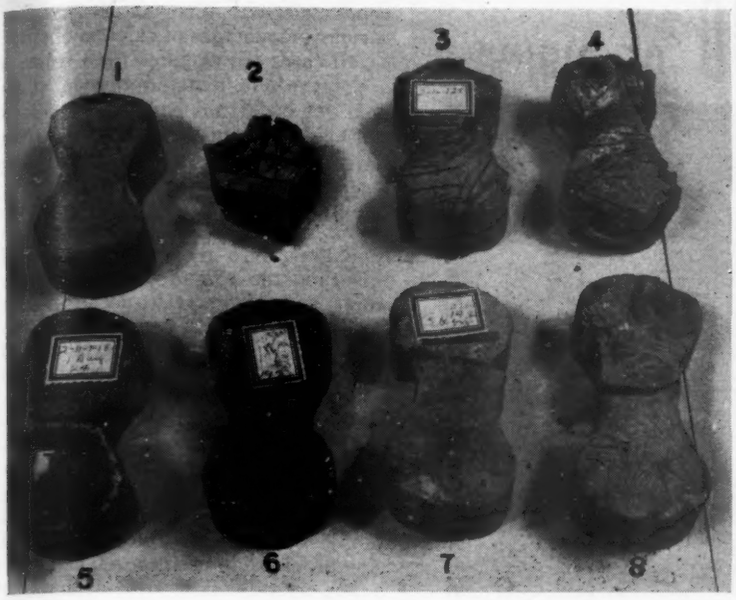

FIG. 10. Samples of different mixes of cement set at normal and sub-normal temperatures.

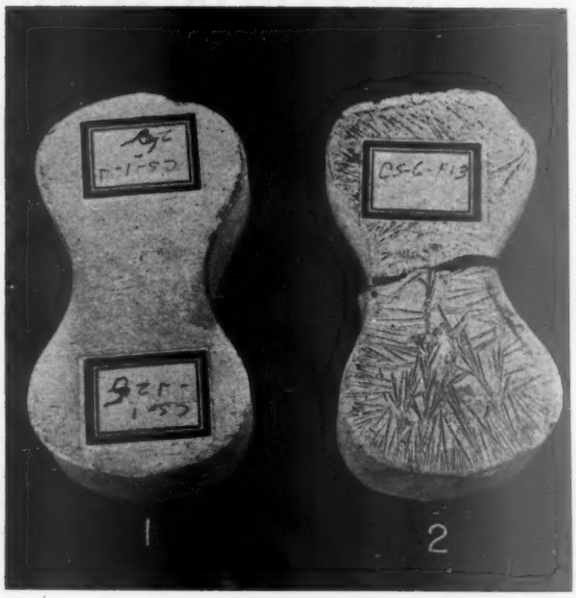

FIG. 11. Samples of gypsum cement set at normal and sub-normal temperatures.

Setting Cements in Below Freezing Conditions

PART 2 — Design and use of cement slurries for cementing casing in permanently frozen ground

MAJOR FOSTER L. WHITE, USAF

Results of Laboratory Tests

Tests with no additives. At the start of making laboratory tests on cements the effect of freezing temperature on standard oil well cement slurries was first determined. The first few samples were set at 28 F and the resultant tensile briquets are pictorially shown as 2, 3, and 4 in Fig. 10. Briquet 2 is Type 3 cement with a .44 w/c ratio. No. 3 is Cement No. 2 with a .44 w/c ratio. No. 4 is Cement No. 4 with a .44 w/c ratio. From these tests it was determined that the development of acicular ice crystals occurs not only at the surface where free water would normally be found due to settling, but throughout the entire mass of cement. It is readily apparent that upon application of heat and melting of the ice, continuous open channels would be present throughout the entire mass. The briquet, labeled as No. 1 in the referenced figure, is Cement No. 3 set at a temperature of 70 F.

As a comparison of what occurs when gypsum cements are frozen, reference is made to Fig. 11. Briquet 1 is a sample set at 70 F. No. 2 is a sample set at 15 F and shows the development of acicular ice crystals but only at the top and bottom and not through the entire mass as was true of other cements.

Tests with $CaCl_2$. Tables 1 through 11 contain the test data of setting times and strengths of the different slurries tested using calcium chloride as an additive. From the tables it can be seen that of the slurries tested, the one having the shortest setting times was Cement No. 3. It may also be noted that in all cases of slurries placed at 15 F with a concentration of less than 8 per cent calcium chloride the samples were frozen within 24 hours. Slurries with concentrations above 8 per cent calcium chloride show a greater resistance to freezing. This can be further determined by comparing tensile strengths of the slurries set at 15 F with strengths obtained at the higher temperatures. In those slurries where bentonite was added the setting times were extended with no apparent resistance to freezing. It is to be noted that the strengths found in slurries tested in a frozen state are greatly in excess of those that would be developed by slurries placed at normal temperature. For the samples tested, there was in general very little change in strength after total freezing had once been accomplished, regardless of age, and in some cases there may have been a decrease in strength. Thickening of slurries containing concentrations of calcium chloride above 8 per cent would probably prevent their being used extensively in oil well work.

Tables 1 and 2 give the results of tests

The Author

Foster L. White, assistant chief of the technical division of the Munitions Board Joint Petroleum Committee has been associated with the oil business most of his life. Beginning in the oil fields at the age of 16, White was graduated from the University of Oklahoma in 1940 with a BS degree in petroleum engineering and after a short period of time with Humble Oil and Refining Company, joined the military service in 1941. In 1946 he accepted a regular commission in the USAF. In 1949 he received a MS degree in petroleum engineering from Tulsa University and after graduation spent approximately one year as a petroleum engineer in Naval Petroleum Reserve Number Four.

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conducted with Cement No. 1 using various percentages of calcium chloride. In all cases the samples were frozen to a point where a determination of the final set could not be made either because of formation of an ice layer on top or freezing of the slurry. During these tests samples of the slurries containing 8 and 10 per cent calcium chloride were set at 15 F for 24 hr at which time they were frozen. At the end of this time the samples were placed in water, and the water frozen around the samples. At the end of a second 24 hr. period these samples were removed and placed in a warm room to thaw and cure in water at 40 F for an additional 72 hr. The strengths thus developed were very low compared with frozen samples, but are probably those that would exist after thawing had taken place and the setting of the cement had been completed. All samples, regardless of the percentage of calcium chloride used, developed acicular ice crystals. After freezing for 24 hr the samples were placed at 70 F. After 3 hr all became soft and had not reached an initial set. Approximately 36 hr were required for these cements to become hard. After hardening under dry conditions, thin layers of the samples spalled off.

Table No. 3 gives the results of tests conducted with Cement No. 2 using various percentages of calcium chloride tested only at 15 F. Above 8 per cent calcium chloride it is doubtful that pumpability could be maintained to accomplish the placement of a slurry in position using this cement. Slurries with 15 per cent calcium chloride were frozen at the end of 72 hr. Lesser concentrations froze in a shorter period of time. When removed to a warm room after being frozen, all became soft, indicating freezing had taken place at some point between the initial and final set. The thawed cement set up and became hard within 24 hr. Fine to very fine acicular ice was formed. After drying, spalling occurred as with slurries of Cement No. 1.

Tables 4 and 5 give the results of tests conducted with Cement No. 3 using various percentages of calcium chloride. There is apparently negligible resistance to freezing of these samples with concentrations of calcium chloride as high as 10 per cent. A comparison of the strengths in Table 5 shows that tensile strengths of the unfrozen set cements are much lower than those of the frozen cements. Briquets marked No. 6 and No. 7 in Fig. 10 are pictures of typical frozen samples of this slurry using calcium chloride as an additive. Briquet 6 contains 2 per cent calcium chloride with a .44 w/c ratio. Briquet 7 contains 10 per cent calcium chloride with a .44 w/c ratio. In both these briquets acicular ice crystals are evident. They are much smaller, finer, and less numerous in Briquet 7 with 10 per cent calcium chloride than that in Briquet 6 with 2 per cent calcium chloride. When these briquets were exposed to room temperatures they became soft. Briquet No. 6 had not reached its initial set. Briquet 7 was apparently just past initial set. Both

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TABLE 1. Initial and final setting times of Cement No. 1 with $CaCl_2$, .44 w/c ratio.

% $CaCl_2$	Setting times Hours: min.	Setting temperatures F 70F	40F	15F
0	Initial set	8:25	—	—
	Final set	16:00 Past	—	—
2	Initial set	6:21	9:31	4:30 Freezing
	Final set	10:01	13:23	5:20 Frozen
4	Initial set	4:56	6:41	5:10 Freezing
	Final set	6:57	11:01	6:45 Frozen
6	Initial set	3:58	5:43	5:37 Freezing
	Final set	6:08	9:33	7:57 Frozen
8	Initial set	3:48	4:58	5:41 Freezing
	Final set	5:26	7:56	8:15 Frozen
10	Initial set	3:06	4:22	5 53 ? Freezing
	Final set	4:48	7:08	8:40 Frozen

TABLE 2. Tensile strength in psi of Cement No. 1 with $CaCl_2$, .44 w/c ratio, setting and testing temperatures 15 F.

Curing time[1] Before testing hours Dry	Wet	Per cent $CaCl_2$ 2	4	6	8	10
24	—	705.5	609.3	302.8	348.3	162.9
72	—	753.3	746.4	660.9	596.1	530.3
48	72 @ 40F	—	—	—	42.3[2]	34.3[2]

[1] Both columns must be added for total curing time.
[2] Set and frozen before curing at 40F. Not frozen at time of test.
Note: All sample partially or totally frozen at time of test unless otherwise noted.

TABLE 3. Initial setting times, final setting times, tensile strength of Cement No. 2 with $CaCl_2$, setting and testing temperature 15 F and w/c ratio .40 unless otherwise noted.

% $CaCl_2$	Setting time hrs: min. Initial	Final	Tensile strength psi 24 hr	72 hr	168 hr
0	—	23:50[1]	—	—	—
2	2:45 freezing	4:26 frozen	526.9	544.0	—
4	3:50 freezing	5:53 frozen	553.1	594.0	—
6	4:20 freezing	6:09 frozen	231.1	388.1	—
8	3:38 freezing	5:09 frozen	200.4	515.5	—
10	5:09 freezing	6:57 frozen	93.5	538.3	—
12	5:17 ? freezing	7:43 ? frozen	46.8	443.8	—
15	3:51	18:24	21.8	397.2	542.8

[1] w/c ratio .44 setting temperature 33F.
[2] Note: All samples with less than 10 per cent CaCl frozen at time of test. Samples with 10 per cent or more CaCl frozen when tested at curing times greater than 24 hours.

TABLE 4. Initial and final setting times of Cement No. 3 with $CaCl_2$, .44 w/c ratio.

% $CaCl_2$	Setting times hours: min.	Setting temperature F 70F	40F	15F
2	Initial set	4:02	6:37	3:00 freezing
	Final set	6:01	8:18	4:20 frozen
4	Initial set	3:41	5:51	5:20 freezing
	Final set	5:48	7:21	6:00 frozen
6	Initial set	2:01	3:29	4:57 freezing
	Final set	3:01	4:42	6:56 frozen
8	Initial set	2:17	3:53	5:16 freezing
	Final set	3:23	5:08	7:06 frozen
10	Initial set	1:54	3:24	4:16 ? freezing
	Final set	2:22	4:23	7:13 ? frozen

set up and became hard cement although rather crumbly and porous in a short period of time, with the sample containing 10 per cent calcium chloride becoming hard in the shortest time.

Tables 6 and 7 give the results of tests conducted with Cement No. 3 using various percentages of calcium chloride with 5 per cent bentonite added to the dry-cement prior to mixing. Samples containing the highest concentration of calcium chloride used were frozen prior to final set. After setting at 15 F for 44 hr, samples containing 10 per cent calcium chloride were placed in water at 70 F for 72 hr, and although hard cement had a tensile strength of less than 7 psi when tested. The sample marked No. 8 of Fig. 10 is a briquet of these slurries set using 4 per cent calcium chloride and is typical of these slurries. The same formation of acicular ice crystals is noted as in other slurries where calcium chloride was used. This sample when placed at room temperature of 70 F became soft and had not reached an initial set prior to freezing. The sample became hard although poor cement in 18 hr.

Tables 8 and 9 give the results of tests conducted with Cement No. 4 using various percentages of calicum chloride. The addition of calcium chloride in high concentrations did not accelerate the setting time of this cement to any reasonable value where freezing of slurry was prevented. When placed at room temperature of 70 F and allowed to thaw these samples became very soft, and had not reached an initial set. Approximately 36 hr were required for these samples to harden into very poor cement. Acicular ice crystals were formed as with previous cements.

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TABLE 5. Tensile strength in psi of Cement No. 3 with $CaCl_2$ .44 w/c ratio.

Setting temp F	Curing time Before testing hr Dry	Wet	Per cent $CaCl_2$ 0	2	4	6	8	10
70	24	—	73.0[1]	—	170.0[1]	210.6	185.0[1]	—
	24	24 @ 70F	107.1	—	177.6	—	—	—
	24	48 @ 70F	263.7[2]	—	328.7	228.8[1]	—	—
40	24	—	8.1	—	46.8	72.4[1]	—	—
	48	—	42.3[1]	—	—	—	—	—
	24	24 @ 40F	—	—	126.4	208.4	—	—
15	24	—	—	428.4	492.4	—	—	—
	72	—	—	—	—	454.0	456.2	454.0
	120	—	—	437.0	551.9	598.5	525.8	446.1

[1] Average of 2 samples
[2] Average of 3 samples

TABLE 6. Initial and final setting times of Cement No. 3 with 5 per cent bentonite with $CaCl_2$.

% $CaCl_2$	w/c ratio	Setting time hours: min.	Setting temperature F 70F	40F	15F
2	.50	Initial set	4:35	8:32	2:01 freezing
		Final set	6:53	12:21	2:41 frozen
4	.55	Initial set	3:42	7:12	6:52 freezing
		Final set	6:02	11:22	7:32 frozen
6	.55	Initial set	2:50	5:50	7:04 freezing
		Final set	5:23	10:40	7:59 frozen
8	.55	Initial set	3:41	5:11	4:49 freezing
		Final set	5:20	9:48	6:38 freezing
10	.60	Initial set	2:32	5:20	5:24 ? freezing
		Final set	3:50	7:38	8:02 ? frozen

TABLE 7. Tensile strength in psi of Cement No. 3 with 5% bentonite with $CaCl_2$.

w/c ratio	Setting temp F	Curing time before testing hr Dry	Wet	Per cent $CaCl_2$ 2	4	6	8	10
.50	15	24	—	483.7	—	—	—	—
		120	—	530.2	—	—	—	—
.55	15	24	—	—	375.6	230.0	—	—
		72	—	—	—	—	415.4	—
		120	—	—	484.8	385.5	422.2	—
.60	15	72	—	—	—	—	—	365.9
		120	—	—	—	—	—	415.4[2]

[1] No break head flaked off sample at limit of travel of beam.
[2] Samples with 10 per cent $CaCl_2$ placed in water for 3 days after being frozen for 48 hr less than 7 psi.
Note: all samples frozen at time of test.

TABLE 8. Initial and final setting times of Cement No. 4 with $CaCl_2$, .44 w/c ratio.

% $CaCl_2$	Setting times hours: min.	Setting temperature F 70F	40F	15F
0	Initial set	—	— 5:33	—
	Final set	—	— 12:00 Frozen	—
2	Initial set	22:51	23:56	3:05 freezing
	Final set	26:21	31:31	3:30 frozen
4	Initial set	21:44	—	5:48 freezing
	Final set	25:29	29:49	7:08 frozen
6	Initial set	—	—	5:57 freezing
	Final set	23:41	26:09	7:03 frozen

* Setting temperature 28 deg.

TABLE 9. Tensile strength in psi of Cement 4 with $CaCl_2$ .44 w/c ratio, setting and testing temperature 15 F.

Dry curing time before testing hours	Per cent $CaCl_2$ 2	4	6
24	606.5	233.4	119.6
72	605.2	523.5	473.4

Note: All samples frozen at time of test.

TABLE 10. Initial and final setting times of Cement No. 5 with $CaCl_2$.

% $CaCl_2$	w/c ratio	Setting times Hours: min.	Temperature F 70F	40F	15F
0	.40	Initial set	5:37	4:30	—
		Final set	5:56	4:46	3:30 frozen
0	.44	Initial set	7:34	5:26	4:10 freezing
		Final set	7:49	5:44	6:00 frozen
2	.44	Initial set	—	10:12	7:58 freezing
		Final set	60:00 past	10:31	9:58 frozen
4	.44	Initial set	—	—	7:44 freezing
		Final set	16:00 past	60:00 past	10:50 frozen
6	.44	Initial set	—	—	5:01 freezing
		Final set	not in 72:00	60:00 past	8:00 frozen

Tables 10 and 11 give the results of tests conducted with Cement No. 5 using various percentages of calcium chloride. Cement slurries without additives were also mixed to obtain comparable data. As this is not a normal oil well cement, the effect of the addition of calcium chloride in greatly increasing the setting times of slurries of this cement was not unexpected. This cement without additives had an unusual characteristic of setting quicker at a temperature of 40 F than at 70 F and at the time of set generated a large amount of heat, which in one case reached a value of 156 F. This cement did not set at 15 F prior to freezing and on freezing developed acicular ice crystals which covered the entire mass of cement comparable to the normal cement slurries set at 28 F and frozen.

Tests With Sodium Bicarbonate. Tables 12 and 13 give the results of tests conducted with Cement No. 3 using various percentages of sodium bicarbonate. The effect of this additive was to extend the setting time. There was no apparent resistance to freezing of the slurries tested. The strengths of these frozen samples are slightly higher than those where calcium chloride was used. The samples containing 6 per cent of this additive exhibited elastic properties and difficulty was experienced in obtaining a break due to stretching of the sample. Acicular ice formation was evident in all samples. Exposure of the samples to a room temperature of 70 F, and subsequent thawing, revealed that the samples had not reached an initial set. Approximately 36 hours were required to harden into poor cement.

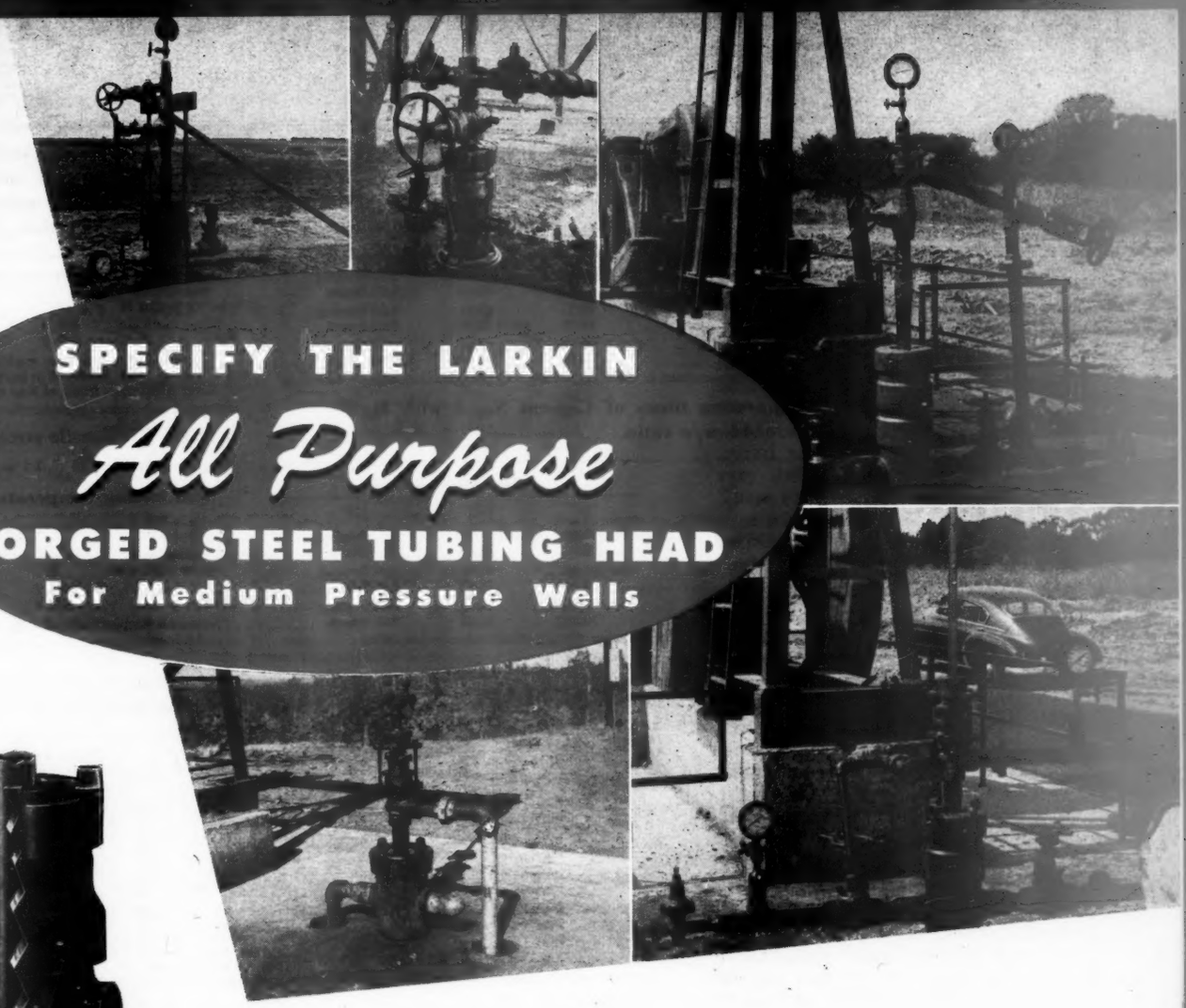
Tests With Magnesium Sulfate. Tables 14 and 15 give the results of tests conducted with Cement No. 3 using various percentages of magnesium sulfate as an additive. The same effect upon extending the setting times was noted here as with sodium bicarbonate. Strengths of these frozen samples are less than those using sodium bicarbonate, however, and are approximately the same as slurries using calcium chloride as an additive. Acicular ice was present throughout the entire mass of cement. On thawing at room temperature of 70 F the samples showed no evidence of initial set. Hardening occurred in 36 hours to very poor cement.

Tests With Sodium Chloride. Tables 16 and 17 give the results of tests conducted with Cement No. 3 using various percentages of sodium chloride as an additive. Sufficient tests were performed on this mixture to determine if these cements would freeze or continue to

TABLE 11. Tensile strength in psi of Cement No. 5, .40 w/c ratio.

Setting temp F	Curing time before testing hr Dry	Wet	Tensile strength psi
40	24	—	137.8
	96	48 @ 70F	241.3
15	24	—	570.1[1]
	72	—	496.2[1]
	96	48 @ 40F	52.7

[1] Frozen at time of test.



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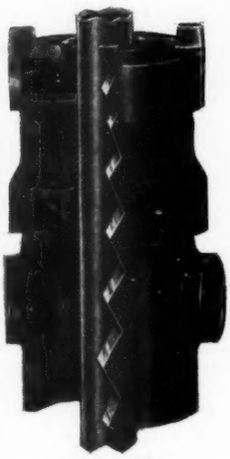

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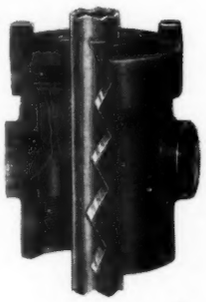

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TABLE 12. Initial and final setting times of Cement No. 3 with sodium bicarbonate, .44 w/c ratio.

Bicarbonate of soda	Setting times hours: min.	Setting temperature F 70F	40F	15F
2	Initial set	8:13	21:43	3:12 freezing
	Final set	12:03	26:13	3:50 frozen
4	Initial set	18:31	25:41	4:30 freezing
	Final set	32:16	not in 36:00	5:00 frozen
6	Initial set	10:16	25:41	5:00 freezing
	Final set	15:16	29:46	5:30 frozen

TABLE 13. Tensile strength in psi of Cement No. 3 with sodium bicarbonate, .44 w/c ratio, setting and testing temperature 15 F.

Dry cutting time before testing hr	Per cent Bicarbonate of soda 2	4	6
48	481.4	630.4	519.0[1]
120	553.0	513.5	380.2[2]

[1] Stretched to near limit of machine before break.
[2] Did not break; stretched to limit of machine.
Note: All samples frozen at time of test.

TABLE 14. Initial and final setting times of Cement No. 3 with $MgSO_4$, .44 w/c ratio.

% $MgSO_4$	Setting times hours: min.	Setting temperature F 70F	40F	15F
2	Initial set	5:54	8:52	2:21 freezing
	Final set	8:09	13:33	3:36 frozen
4	Initial set	6:17	11:45	4:08 freezing
	Final set	8:34	17:12	5:30 frozen
6	Initial set	7:48	11:55	4:39 freezing
	Final set	10:15	17:25	6:00 frozen

TABLE 15. Tensile strength psi cement No. 3 with $MgSO_4$, .44 w/c ratio, setting and testing temperature of 15 F*.

Dry curing time before testing hr	Per cent $MgSO_4$ 2	4	6
72	431.1	417.7	432.5
120	336.9	530.5	406.3

*Note: All samples frozen at time of test.

set at 15 F where the freezing point of the mixing water used was depressed to a point below 15 F. In no case was the development of acicular ice crystals noted with any concentration of NaCl tested. There was no difficulty encountered in obtaining slurries sufficiently fluid for pumpability regardless of the concentration of NaCl used. Samples containing less than 10 per cent sodium chloride, when set at 15 F, were frozen, and, when placed in a warm room became slightly soft, and indicated that they had reached a point between the initial and final sets. These samples hardens in a short period of time and became good cement although an increase in permeability may have occurred. The slurries containing concentrations of 10 per cent sodium chloride or above did not freeze when set at temperatures of 15 F.

The time required for initial and final set was greatly increased. This can best be shown by noting on Table 17 the very slow development of tensile strength with time for those samples that were tested. At concentrations of 12 per cent and above, the freezing point of the mixing water was lower than that which might be encountered in the permafrost and these slurries became a set cement capable of performing the normal functions of oil well cements but with a greatly extended setting time. These cements when placed at room temperature remained good cement with no softening at concentrations of 12 and 15 per cent. Removal of samples set at 15 F to a curing bath at a temperature of 70 F increased the tensile strength of the cement more rap-

TABLE 16. Initial and final setting times of Cement No. 3 with NaCl, .44 w/c ratio.

% NaCl	Setting time hours: min.	Setting temperature of 70F	40F	15F
0	Initial set	4:56	9:56	
	Final set	8:01	16:30 past	frozen in 4 hr
8	Initial set	3:58	6:13	
	Final set	5:04	7:43	? frozen in 14 hr
10	Initial set	3:50	6:20	19:45
	Final set	4:39	8:04	32:45
12	Initial set	3:43	7:10	21:41
	Final set	5:43	10:02	31:41
15	Initial set	5:27	7:57	35:26
	Final set	8:12	10:12	56:56

TABLE 17. Tensile strength in psi of Cement No. 3 with NaCl, .44 w/c ratio.

setting temp	Curing time before testing hr Dry	Wet	Per cent NaCl 0	8	10	12	15
70	24	—	73[2]	—	146.9[2]	134.3[2]	—
	24	24 @ 70F	107.1	—	—	—	—
	24	48 @ 70F	263.7[2]		203.8[2]	212.8[2]	
40	24	—	8.1	—	—	36.2[2]	—
	24	24 @ 40F	42.3	—	—	—	—
	24	48 @ 40F				272.2	
15	48	—	—	32.0	16.1	9.9[2]	—
	72	—	—	—	33.0	39.3[2]	—
	48	24 @ 70F	—	—	69.6	86.6	—
	96	—	—	35.4	22.9	—	—
	72	24 @ 40F	—	—	—	—	42.2
	48	48 @ 70F	—	37.7	44.5	—	—
	120	—	—	—	—	75.2	74.1

[1] Both columns must be added for total curing time.
[2] Average 3 samples
[3] Average 2 samples

TABLE 18. Initial setting times, final setting times, and tensile strength of Cement No. 2 with NaCl, setting and testing temperature 15 F.

% NaCl	Setting time hr: min initial	final	Tensile strength psi 48 hr	72 hr	240 hr
6	3:33	5:51	21.8	105.3[1]	348.3[1]
8	4:59	7:16	< >	36.5	—
10	16:59	48:00 past	No tests—samples broken on removal from mold.		

[1] Frozen at time of test.

TABLE 19. Initial and final setting times of 60 minute gypsum cement.

w/c ratio	Setting time hours: min.	Setting temperature F 70F	40F	28F	15F
.40	Initial set	1:13	1:25	—	2:00
	Final set	1:39	2:00	—	2:24
.44	Initial set	:57	1:22	1:35	1:56
	Final set	1:09	1:46	2:00	2:19
.44	Initial set	1:25	—	—	2:29
	Final set	1:43	—	—	—

Mixing water contained 4 per cent CaCl.

TABLE 20. Tensile strength in psi of 60 minute gypsum cement.

w/c ratio	Setting temp	Tensile strength psi 1 hr after final set	24 hr
.40	70	176.5	—
	15	160.6	—
.44	70	146.9	195.8
	15	159.4	—

TABLE 21. Initial and final setting times of 60 minute gypsum cement with various cements.

w/c ratio	Per cent gypsum cement	Type of cement used for remainder	Setting times hours: min.	Setting temperatures F 70F	40F	15F
.40	50	No. 3	Initial set	:03	—	—
			Final set	:05	—	—
.44	50	No. 3	Initial set	—	:06	:05
			Final set	—	:09	:08
.55	50	No. 3	Initial set	:07	:07	:08
			Final set	:16	:16	:18
.50	25	No. 3	Initial set	:06	:06	:07
			Final set	:16	:16	:18
.50	20	No. 3	Initial set	:07	:07	:08
			Final set	:11	:11	:13
.50	50	No. 1	Initial set	2:57	3:15	3:42
			Final set	3:08	3:34	4:16
.50	50	No. 2	Initial set	:38	:45	:47
			Final set	:51	:59	1:20
.50	50	No. 4	Initial set	1:29	1:56	Indeterminate
			Final set	1:40	2:17	Ice layer on top
.44	20	No. 2	Initial set	:39	:52	1:11
			Final set	2:31	2:49	1:52 ? frozen
.44	10	No. 2	Initial set	:47	1:02	1:26 ? freezing
			Final set	1:27	12:03	1:40 ? frozen
.50	80	No. 2	Initial set	:44	:49	1:05
			Final set	:59	1:05	1:30

TABLE 22. Tensile strength in psi of 60 minute gypsum cement with various cements setting and testing temperature 15 F.

w/c ratio	Per cent gypsum cement	Type of cement used for remainder	Tensile strength psi 24 hr	72 hr	120 hr	144 hr	168 hr
.44	50	No. 3	1167.4	1167.4	—	—	1165.1
.55	50	No. 3	1001.3*	1016.1*	—	—	—
.50	50	No. 1	678.2	681.6	—	—	—
.50	50	No. 2	856.8	902.3***	—	—	—
.50	50	No. 4	545.0	489.4	—	—	—
.44	20	No. 2	870.4	—	—	786.3	—
.44	10	No. 2	671.1	9.5#	—	—	—
.50	80	No. 2	668.0	—	935.3	—	—

* Break not obtained, sample head compressed allowing beam to reach limit of travel.
*** Permeability tests this sample 15 md horizontal 19 md vertical.
# 24 hours dry cured at 15F. 48 hours wet cured at 70F.
Note: All samples frozen at time of test unless otherwise noted.

idly than if left at 15 F for the entire curing period. This was true of no other cement tested.

Table 18 gives the results of tests conducted with Cement No. 2 using various percentages of sodium chloride as an additive. Of the three samples tested those with less than 8 per cent sodium chloride froze but the sample containing 10 per cent sodium chloride did not freeze. For the frozen samples, strengths were still low and it is probable that freezing of the entire sample did not take place until some time after final set had been recorded. This was probably an erroneous indication of setting time because of the formation of an ice layer on top of the sample. On being exposed to thawing at a room temperature of 70 F the slurry containing 6 per cent NaCl had not reached its initial set, the 8 per cent sample was past the initial but not to a final set and the 10 per cent sample had reached its final set. The 6 and 8 per cent samples became hard and very good cement after 12 hr at 70 F. No acicular ice formed in these samples at the 15 F temperature.

Tests With Gypsum Cements. Tables 19 and 20 give the results of tests conducted with gypsum cement. There was some fluctuation in the setting times due to composition of the water used for mixing. The times quoted herein are an average using water from lakes scattered throughout the Reserve. These waters selected from different parts of the Reserve show that only a slight fluctuation was experienced in setting times regardless of the location of the water used. The addition of calcium chloride to the mixing water when using gypsum cements had the effect of extending the setting time. Samples set at 15 F reached a final set with a layer of thin acicular ice formed at top and bottom. As further evidence of the fact that these samples were unfrozen at the time of final set, the tensile strengths were within the allowable limits of normal strength this type of cement would develop. Samples placed at room temperature of 70 F showed no evidence of thawing except for the thin acicular ice layer.

Tests With Mixtures of Gypsum and Other Cements. Tables 21 and 22 give the results of tests conducted with gypsum cement mixed with different kinds and percentages of the normal cements previously tested. The type of cement mixed with the gypsum cement had a very definite effect upon setting time. There was very little difference in setting time with an increase or decrease of w/c ratio. It is possible that such cements could be designed to set in a given period of time. The one that showed good results for probable top hole use was a 50-50 mixture of gypsum cement and Cement No. 2. Further investigation of this sample revealed that the permeability was 15 md horizontal and 19 md vertical. These mixtures may develop permeabilities that would be considered excessive for oil well work. The strengths developed from the freezing of these slurries were the largest found in all the tests that were conducted. Mixtures of gypsum cement containing Cement No. 3 were the strongest. Upon exposure to a room temperature of 70 F and consequent thawing, the softness of the sample was inversely proportional to the percentage of gypsum cement used. With a high percentage of gypsum cement very little softening was noted. Acicular ice formation was common in all samples.

Thickening Time Tests. At the completion of setting time and tensile strength tests those cements that were considered to be usable under the conditions encountered within and immediately below the permafrost section were tested for pumpability time. Results of

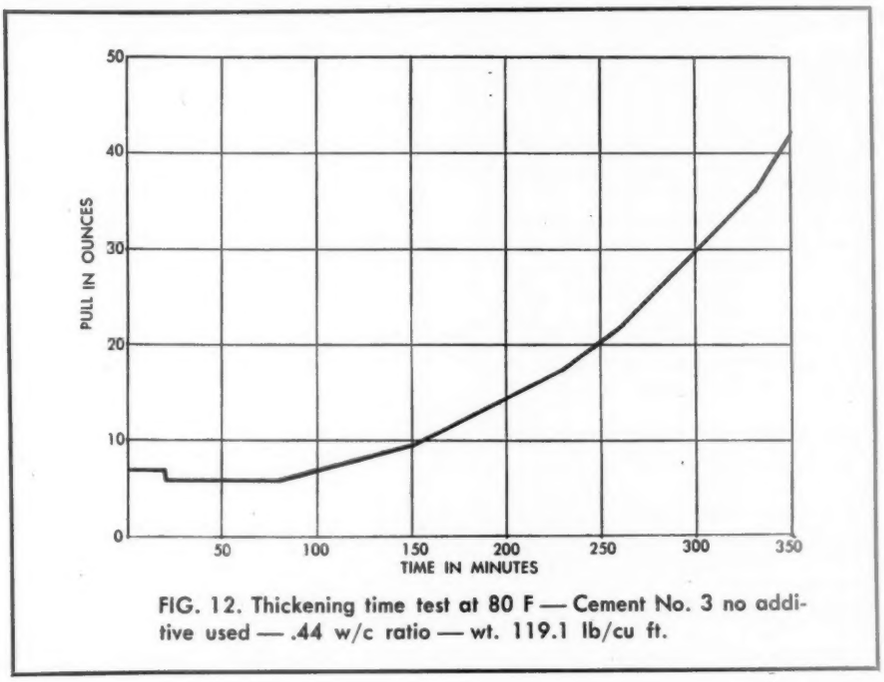


FIG. 12. Thickening time test at 80 F — Cement No. 3 no additive used — .44 w/c ratio — wt. 119.1 lb/cu ft.

these tests shown in Figs. 12 through 17.

Fig. 12 gives the results of a thickening time test with a slurry of Cement No. 3 to which no chemical has been added and with the bath temperature maintained at 80 F for the duration of the test. This is presented as comparative data for the other tests where additives were used. The time required for this slurry to reach a pull of 40 oz was 344 minutes.

Fig. 13 gives the results of a thickening time test of Cement No. 3 with 4 per cent calcium chloride, and with the bath temperature maintained at 80 F for the duration of the test. The time required for this slurry to reach a pull of 40 oz was 140 minutes.

Fig. 14 gives the results of a thickening time test of a slurry of Cement No. 3 with 6 per cent calcium chloride, and with the bath temperature maintained at 80 F for the duration of the test. The time required for this slurry to reach a pull of 40 oz was 119 minutes.

To determine the consistency of these slurries at lower temperatures, the higher concentration of 6 per cent calcium chloride was tested at simulated well bore conditions. These data are presented in Fig. 15. For this test the bath temperature was established at 40 F using a Prestone and water mixture for the bath. The slurry was mixed at the approximate temperatures that it was felt could be accomplished in the field. The bath temperature of the tester was allowed to cool below the freezing point of water while the test was in progress. At the end of 400 minutes when the bath temperature was near the freezing point the thickening of the slurry had almost ceased and after passing the freezing temperature, leveled out at a constant value of 23 oz of pull. Continuation of the test resulted in a decreased pull.

Fig. 16 gives the results of a thickening time test of a slurry of Cement No. 3 with 12 per cent sodium chloride, and with the bath temperature maintained at 80 F for the duration of the test. The time required for this slurry to reach a pull of 40 oz was 270 minutes.

Fig. 17 gives the results of a thickening time test of a slurry of Cement No. 3 with 12 per cent sodium chloride, conducted under simulated well bore conditions. When the temperature of the bath decreased below the freezing point the pull continued to increase slowly. It is believed that from the previous data of setting times of slurries of this cement placed at 15 F, the slurry would continue to thicken and would reach a pull of 40 oz at some time approaching the time of initial set, probably in the vicinity of 36 to 48 hr.

Discussion of Laboratory Data

From the results of the tests conducted herein, slurries of cements mixed with water containing calcium chloride will probably freeze before setting if placed at low temperatures and if thawed after freezing and allowed to set will be very poor cements. Such cements would probably contain open channels because of acicular ice formation. Of all the cements tested, Cement No. 3 exhibits the best properties for use above freezing. In using slurries containing Cement No. 3 and calcium chloride during the period of top hole drilling, and where the walls of the well have not had the chance to absorb a great amount of heat, it is doubtful that freezing could be prevented before such cements had reached their final set, at least at the formation face. After placing such cements in position and allowing them to freeze, then thaw, the bond between the cement and the formation may be sufficiently porous to allow the passage of fluids. Cement No. 3 containing a concentration as high as 8 per cent calcium chloride should remain pumpable for a sufficient period of time to be placed in position above 1500 ft and should result in a sufficiently strong cement at temperatures above 40 F so that drilling could be resumed within 48 hours.

From the data presented herein, two of the slurries tested would probably give the desired results at temperatures below 40 F. These are Cement No. 3 containing sodium chloride and the gypsum cement. The setting time of the gypsum cement is sufficiently unaffected by low temperatures that it should reach a final set condition before the slurry could cool down enough to freeze. Setting times of 60-min gypsum cement at 15 F should in no case be longer than 2 hr and

FIG. 13. Thickening time test at 80 F. — Cement No. 3 with 4% Ca Cl_2 — .44 w/c ratio. — Wt 118.2 lb/cu ft.

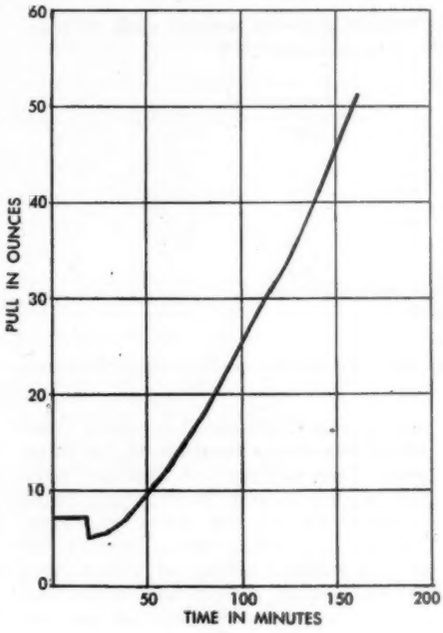


FIG. 14. Thickening time test at 80 F. — Cement No. 3 with 6% Ca Cl_2 — .44 w/c ratio. — Wt. 119.5 lb/cu ft.

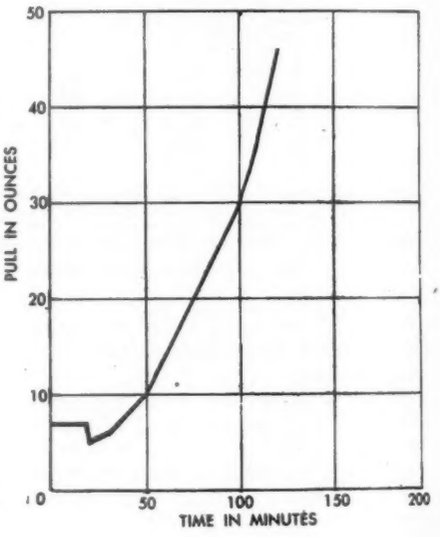
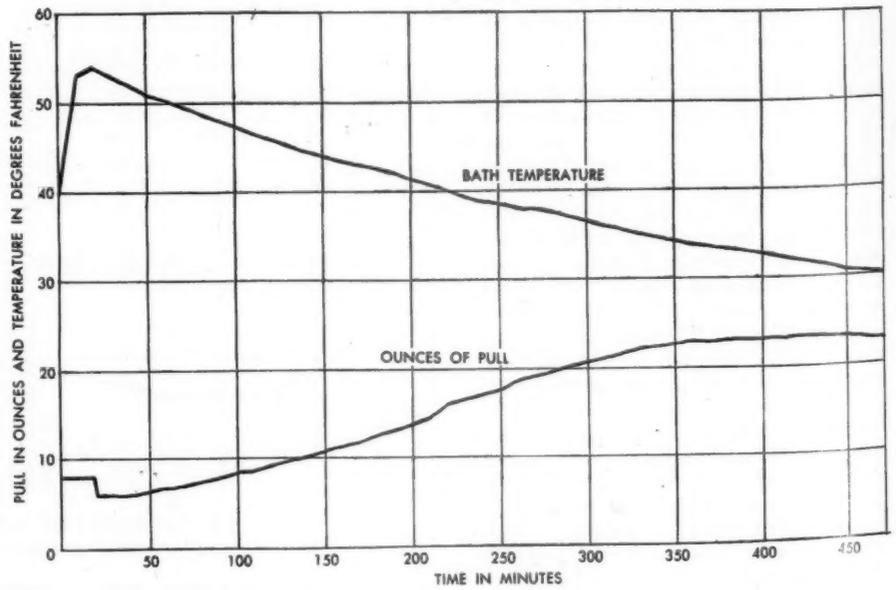


FIG. 15. Thickening time test at low temperature — Cement No. 3 with 6% Ca Cl_2 — .44 w/c ratio. — Wt. 119.0 lb/cu ft — slurry temperature 90 F.



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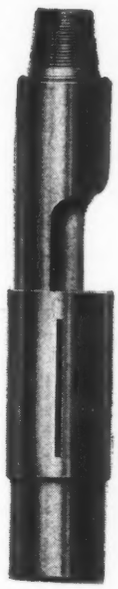

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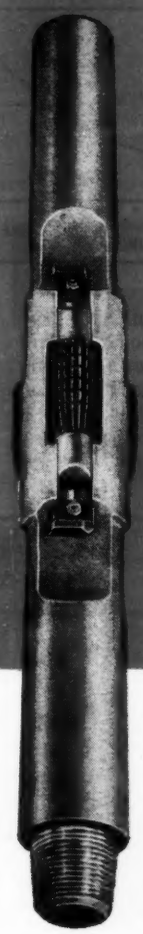

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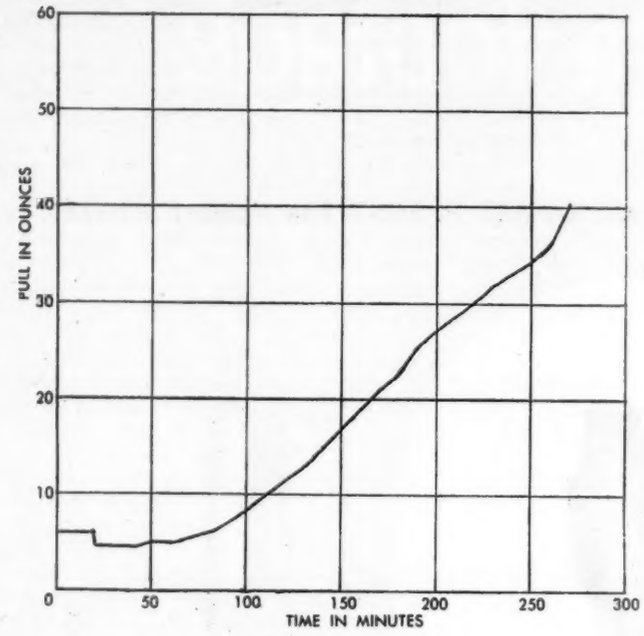
FIG. 16. Thickening time test at 80 F — Cement No. 3 with 12% NaCl — .44 w/c ratio — wt. 118.7 lb/cu ft.



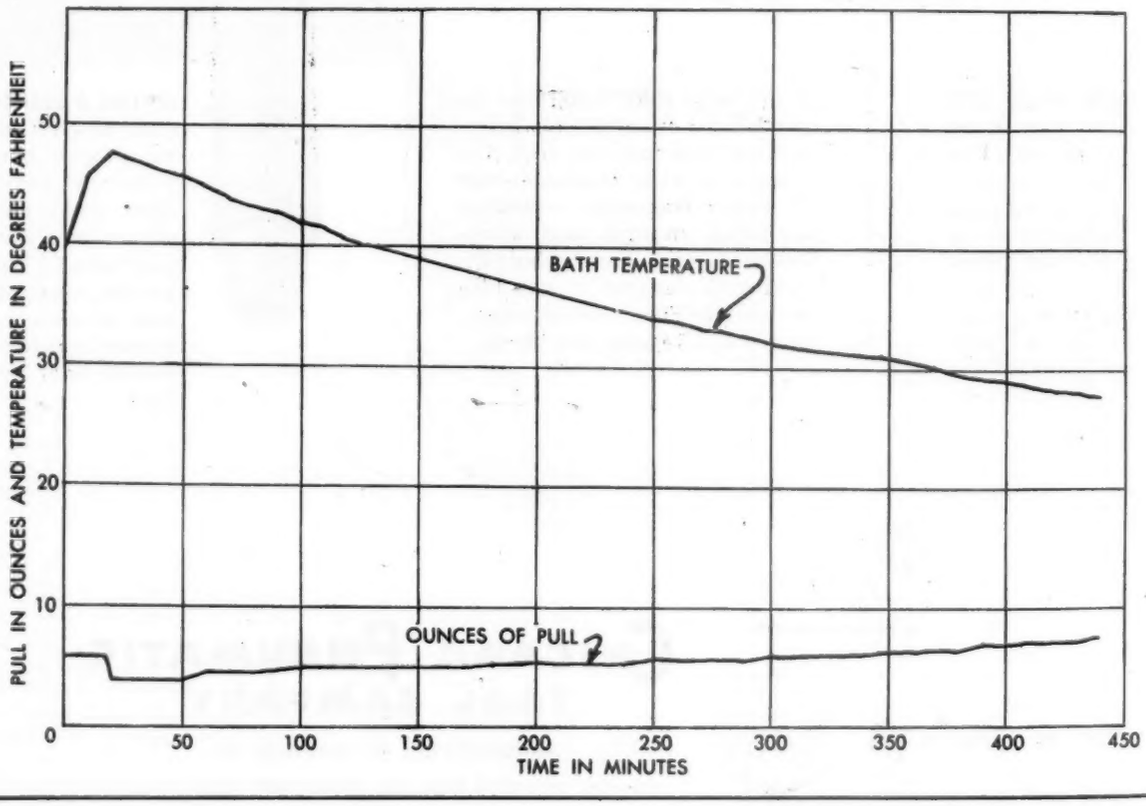
30 min. This would allow sufficient time to place the slurry in position and reach final set without difficulty. Using this type of cement and creating a temperature of 40 F at the wall of the well bore would keep the cement above freezing point for a time sufficient for setting, especially since the latent heat of fusion of water would tend to maintain the temperature of the well bore at 32 F for a period of time. The length of this relatively warm period would be longer than that needed for the cement to set. With the use of gypsum cements and their setting qualities under cold conditions, the strength developed is greatly in excess of that deemed necessary and should result in a speeding up of operations, thereby decreasing the amount of rig time required for waiting on the cement to set.

Slurries of Cement 3 containing sodium chloride in high percentages to depress the freezing point of the mixing water below that to be encountered in the permafrost, would set and give satisfactory results. Such cements would have a very long setting time and actual development of their strength and permanent qualities would not be obtained until after circulation had again been established and temperature of the cement increased.

Field Tests

At the time of the writing of this paper only one hole has been drilled in which cements tested herein have been used. The casing program for this particular well called for a short string of 16⅝-in. pipe cemented at 90 ft. The top two 30-ft joints of 16⅝-in. pipe were jacketed with a 23-in. pipe. The smaller diameter pipe was centered inside the larger pipe and the large diameter pipe sealed on the top and bottom by welding. This enclosed a dead air space between the two casings. This dead air space acts as an insulator in preventing rapid heat transfer from the drilling fluid to the formation, thereby decreasing the amount of thawing of the top formations. While drilling top hole for this conductor pipe,

FIG. 17. Thickening time test at low temperature — Cement No. 3 with 12% NaCl—.44 w/c ration—wt. 119.3 lb/cu ft—slurry temperature 64 F.



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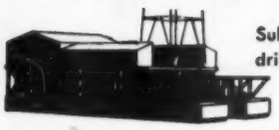
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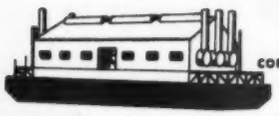
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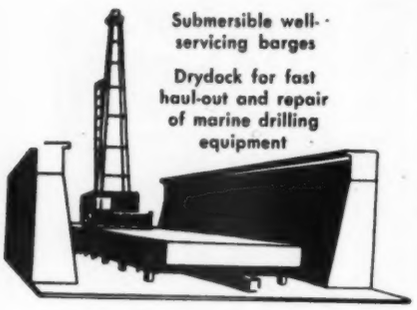
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returns were circulated out of the cellar.

Based upon the data presented in this paper it was decided that gypsum cement slurry would be used and sufficient slurry mixed to fill the annulus to the bottom of the cellar. As heavy a slurry as possible was mixed and pumped down behind a large slug of water that was used to clean the mud from the inside of the pipe and the walls of the well, preventing contamination of the cement. Drilling out of the cement plug was accomplished in 30 hours after mixing. Drilling was then continued to a depth of approximately 2320 ft, and no trouble with leakage was encountered with the top conductor pipe, a condition that has not normally been experienced with the other holes drilled in the Reserve.

At this depth a second string of 10¾-in. pipe was set and cemented. The slurry used for this job consisted of standard construction Portland cement mixed with water containing 4 per cent calcium chloride. After mixing, slurry temperature was 70 F and formation temperature was estimated to be 60 F. Attempts were made at the end of 48 hr to drill out and core the 30 ft of cement remaining in the pipe. Due to a rig breakdown the core was not obtained until the end of approximately 72 hr. The core obtained was a dense, compact, well-set cement.

Discussion of Field Tests

Standard oil well experience with cementing casing in the field has shown that necessary work will not usually permit drilling out the cement plug by the time the required strength has been reached. Where low formation temperatures are present this will not be true with certain cements. By the use of gpysum cements, which will set in a short period of time, the consequent saving in rig time will more than offset the added cost of the cements. It is believed that the concentration of calcium chloride used in cementing the 10¾ in. for this hole could probably be increased 6 to 8 per cent in holes where the pipe is set above 1500 ft. The increase in concentration of calcium chloride used should shorten the setting times, and approximate the time discussed here for the 4 per cent $CaCl_2$ slurry, placed at 2320 ft.

Conclusions

1. Gypsum cements used within the permafrost section will set and become a hard, impervious mass prior to the time they become frozen. Although not so permanent a substance as standard portland cements, such cements will give satisfactory results and will be sufficiently so until a longer string of pipe can be placed and cemented below the perma-frost section using normal oil well cements.

2. Cements containing sodium chloride in concentrations above 10 per cent will set and develop the strength necessary for casing work when placed at low temperatures. These cements will have a greatly extended setting time, with a consequent loss of rig time because of waiting on cement.

3. Cements using calcium chloride as an additive will set at temperatures above freezing and give satisfactory cement jobs. At temperatures below freezing there is a possibility of formation of acicular ice crystals with all calcium chloride cements that could be pumped into the well. Such cements, if frozen, will be of extremely poor quality on thawing and probably will result in an unsuccessful job under freezing conditions.

4. Magnesium sulphate and sodium bicarbonate as additives to cements are unsatisfactory for casing cementing jobs.

5. Gypsum cements containing other cements in a dry mixture may be designed to develop desirable setting times but with probable increases in permeability above that deemed desirable for casing cementing jobs.

Acknowledgments

Acknowledgment is gratefully made to the director of Naval Petroleum Reserves for permission to publish this paper and to the Petroleum Engineering Department of the University of Oklahoma for permission to utilize data for this article, which have been included in a thesis presented to the University. Thanks and appreciation are also due Gene Davis, project manager, and Karl VonderAhe, chief petroleum engineer of Arctic Contractors for their aid and criticism during the development of the work reported herein and to the many people of Arctic Contractors who assisted in the preparation of this paper. The comments and suggestions of Hayden Roberts and Francis Anderson of Halliburton Oil Well Cementing Company; George Cannon of Humble Oil and Refining Company; and George Howard of Stanolind Oil and Gas Company are also acknowledged.

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* * *

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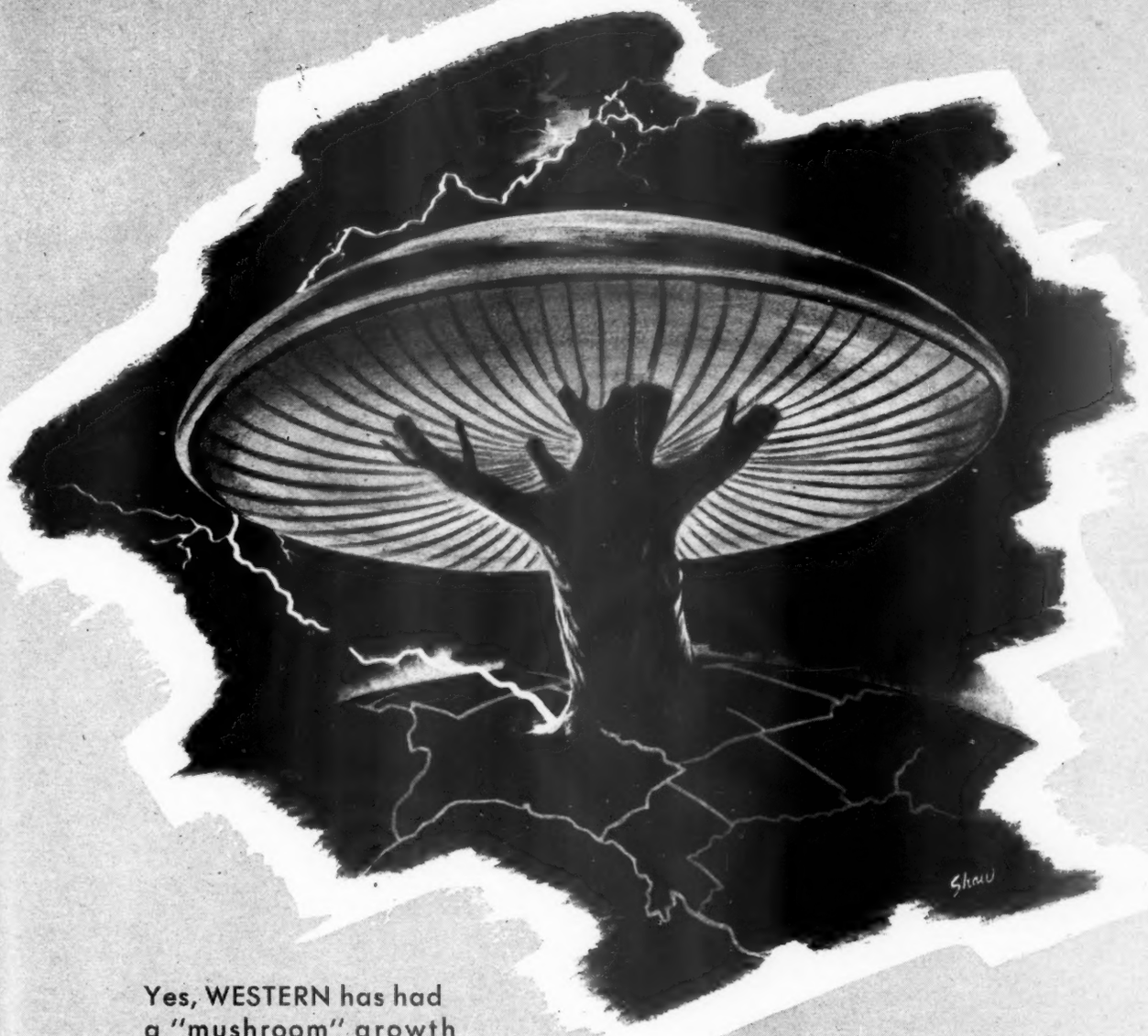

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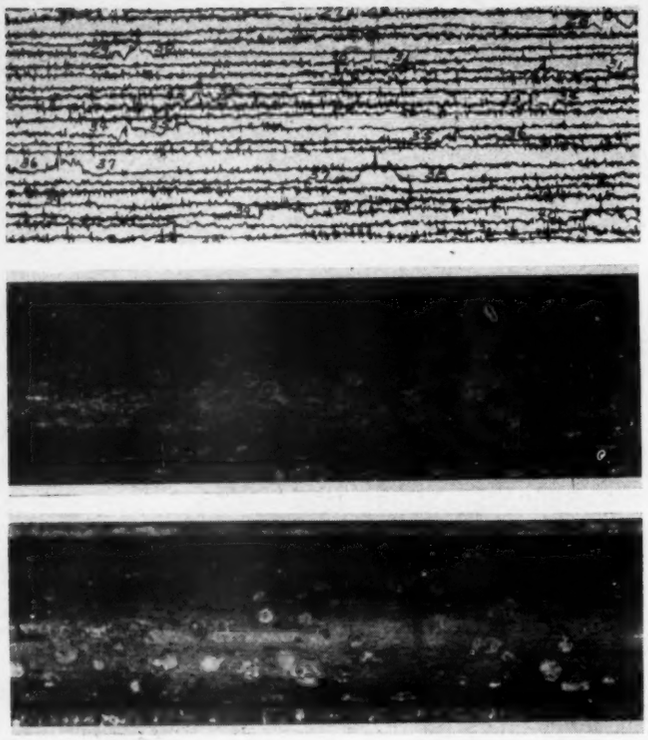


FIG. 1. Typical attack high pressure sweet oil well corrosion.

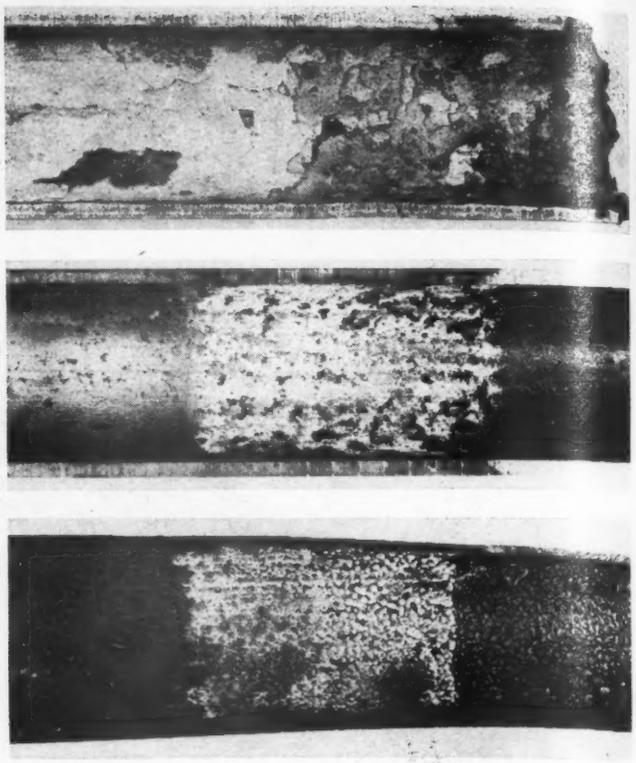


FIG. 2. Typical scale formation.

Sweet Oil Well Corrosion†

Prevention is doubly important now — for conservation of steel as well as for economic considerations

H. L. BILHARTZ*

THE problem of sweet oil well corrosion has been recognized as one of economic importance within recent years. In 1945 attack on tubing in high pressure sweet oil wells in southeastern Louisiana was observed for the first time. Its seriousness was not fully comprehended until 1948 when a high pressure well blew out as a direct result of corrosion. The monetary loss of this single failure was $150,000 plus loss of the well. Subsequently one-half million dollars were spent on corrosion in this field by one company in one year.

Careful investigation by other companies revealed that serious corrosion was occurring in most wells in the general geographic area.

This particular problem constitutes one of the two major concerns of the corrosion engineer interested in "sweet" oil well corrosion.

The other deals with lower pressure wells and was recognized even more recently. It is predicted that corrosion costs chargeable to this single problem will be approximately $3,000,000 this year. For the sake of expediency the two projects have been named by industry as (1) "High Pressure Sweet Oil Well Corrosion" and (2) "Low Pressure Sweet Oil Well Corrosion."

This vague terminology will suffice for current consideration. It is quite probable, however, that with the advent of a clearer understanding of the mechanism of attack, the two problems will be closely related. The principal differences at this time are twofold:

1. Severe corrosion has been noted under "high" pressure conditions where little or no water is produced. By contrast, a critical water-oil ratio must be exceeded before perceptible attack occurs in the "low" pressure category.
2. Corrosion becomes active immediately after production is commenced in the "high" pressure environment, whereas, many years (10-15) of corrosion-free operation has been observed in the other category before serious metal loss occurs.

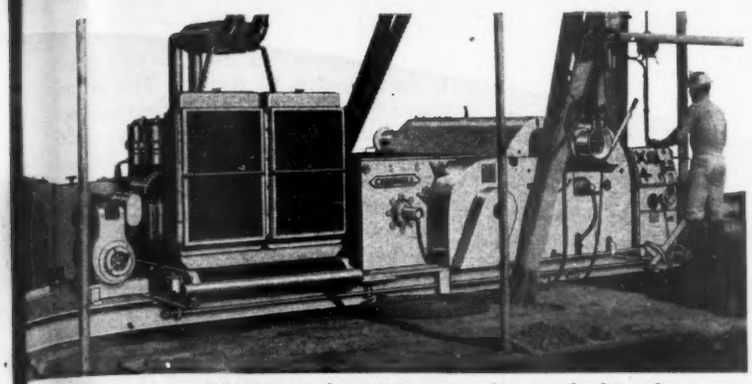
This paper will discuss briefly these two problems from a standpoint of investigative approach, criteria, causative agents, and remedial measures.

Method of Approach

The initial approach of study was very similar in both instances. It became apparent shortly after recognition of the problems that cooperative effort between producing companies could expedite an economical solution. The Technical Practices Committee framework of the National Association of Corrosion Engineers provided an excellent clearing house or forum whereby some 30 participating companies could pool their technical effort. A sub-committee of the Oil and Gas Production committee was founded to consider all aspects of

†Presented at the Spring Meeting of the Southwestern District, API Division of Production, Washington-Youree Hotel, Shreveport, Louisiana, March 5-6-7, 1952.

*The Atlantic Refining Company, Dallas, Texas.



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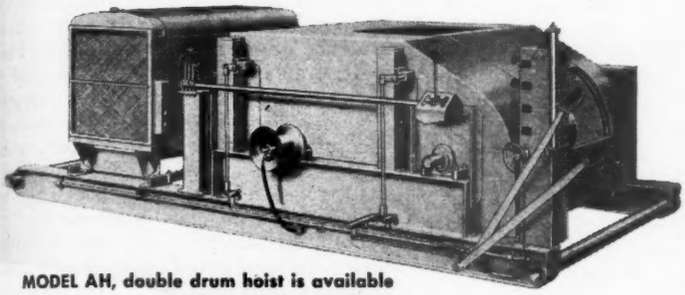

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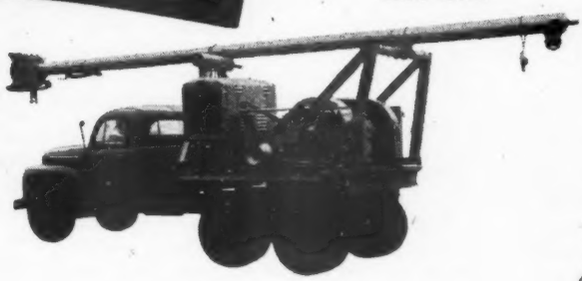

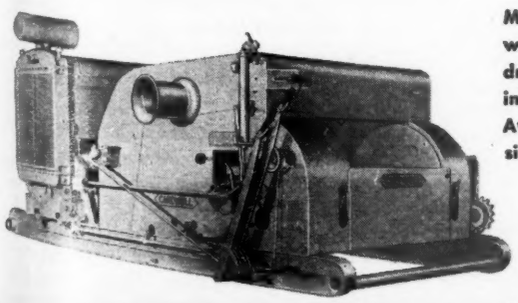

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"sweet" oil well corrosion. Through the combined efforts of technical men from these companies, progress was far more rapid than could have been possible with engineers working individually.

High Pressure Project

In order to develop definitive data pertaining to the "high" pressure problem, a questionnaire was submitted to all companies participating in the NACE committee. The questionnaire considered the correlation of various producing variables with rate of corrosion, the scope of the problem, causative agents, criteria, and remedial measures. Data obtained from this survey revealed many characteristics unique in this problem.

General pitting (Fig. 1) similar to that experienced in condensate wells was reported. An average of 75 pits per linear foot were observed in some sections of tubing removed from corrosive wells. These pits were characteristic of carbon dioxide attack. Subsequent analysis proved this acid gas to be the primary causative agent. Organic acids were detected in unusually large concentrations. It was concluded that they constituted a secondary causative agent.

The intensity of corrosion was noted to vary a great deal within a field. In rare instances complete penetrations developed in one year. On the other hand 8 or 10 years of trouble-free service were experienced on off-set wells. In general the average tubing life was 3 to 4 years. Ringworm corrosion as shown in Fig. 2 was rare, but it proved troublesome and costly during workover operations.

Possibly the most striking observation was the fact that severe corrosion occurred in wells producing pipe line oil. Traces of water, officially reported as 0.1 per cent, were sufficient to radically reduce tubing life. To the author's knowledge this phenomenon had never before been recorded. Under these circumstances it was and is difficult to explain the exact mechanism of attack. Various theories, which are beyond the scope of this paper, leave much to be desired in the way of a rigorous explanation.

Scale conditions noted also defied explanation. Two types of scale (Fig. 2) were reported; one was a thick, heavy, white, cement-like material that proved to be barium sulfate, and the other a red oxide-appearing coating over a thin barium sulfate deposit. The red overcoating was honey-combed in appearance and very hard.

The scale deposition became of more than academic interest when it was realized that such a hard material seriously affected the results of tubing caliper surveys. Such surveys normally dictate workover operations. The affect is best illustrated in Fig. 3. A substantial increase in pit depth was measured subsequent to scale removal. In addition the visually determined frequency of pitting increased by a factor of 10 after tubing had been cleaned of scale.

Criteria of corrosion for a given environment are always difficult to establish. It was at first assumed, because of the similarity of attack, that the criteria so laboriously arrived at during the concentrated investigation of condensate well corrosion would be applicable. Factors considered in these criteria were as follows:

1. Surface coupon tests.
2. Iron content determination.
3. Carbon dioxide content.
4. Organic acid content.
5. Tubing caliper surveys.

Surface coupon tests in this problem proved to be of no value because of severe paraffin deposition. Iron concentration was of little significance as it was practically impossible to sample water produced from "pipe line" oil. In wells where significant water was produced correlation of corrosion rate versus iron content was poor. There *was* a correlation with carbon dioxide and organic acids. As discussed previously it was concluded that these two compounds constituted the causative corrosion agents.

The value of the tubing caliper, though still important, was obscured by the unique scaling conditions; thus, rendering interpretation of data difficult.

It will be recalled that a questionnaire was submitted to members of NACE TP-1 committee. Fig. 4 illustrates the results of the statistical section of the questionnaire. It may be seen that 42 per cent of the wells in the subject category displayed tubing corrosion and 20 per cent surface equipment attack.

There was *no* correlation with age of wells signifying that corrosion became evident very soon after production was started. A direct correlation was noted with oil production rate. As expected from preliminary observations, no correlation was derived from per cent or total water production.

Paraffin, emulsion, and sand problems were equally independent of corrosion rate. A reasonable correlation with bottom-hole pressure was observed, with increased pressure resulting in increased corrosion. Bottom-hole temperature displayed a significant pattern. Corrosion incidence was directly related to temperature. Surface tubing pressure and gas-oil ratio displayed little related evidence. A direct correlation existed between corrosion frequency and well depth. The latter is especially significant for several reasons. First, workover costs on these wells are particularly high, and, second, the trend is toward deeper drilling, especially in southeastern Louisiana where this problem has been most prevalent. These factors would indicate that economic stakes of this problem will increase in the years to come.

The development of economical remedial measures proved difficult. Most commonly employed techniques were inadequate or could not be economically applied.

Thermosetting plastic coated tubing was installed in the early days. Fig. 5 illustrates its effectiveness. It *did* reduce general attack, but isolated pits began to form within 19 months. The advantage of this technique was thus subjected to some doubt because one complete penetration in a 10,000-ft well necessitated a workover. In all fairness to this approach it must be emphasized that the product used during early days of test has been improved. Subsequent tests may tend to minimize the noted disadvantage. Thermosetting plastic coated tubing costs approximately twice that of unprotected pipe. Three hundred ten thousand feet have been installed to date in wells of the subject category.

Nine per cent nickel tubing was installed originally because of its successful use in the condensate well environment. Approximately 100,000 ft have been installed in one area of southeastern Louisiana. To date only minor evidence of attack has been noted. Fig. 5 illustrates the perfect condition of 9 per cent nickel after one year's service. Nine per cent nickel tubing costs 3.8 times that of J-55. Unfortunately this material is no longer available to the oil industry, so it has become necessary to develop other methods of alleviation.

Both galvanized and nickel-plated pipe have been tested under in-hole conditions. Galvanizing failed immediately. Results of the tests of nickel-plated tubing are not yet available. The data when received, however, will be of academic interest as this material, too, is no longer available for use in this manner.

The use of inhibitors was at first thought to be impractical because of inherent difficulties encountered in releasing inhibitor in the bottom of the well. Due to the high pressures involved, packers and mud filled annular spaces were almost universally accepted as necessary. Therefore, the only means of introducing inhibitor was through the tubing. As the tubing was always full of produced fluid, it was necessary that weighted stick inhibitors be employed. The cost of adequate treatment in many instances equals that of replacing tubing every 3 or 4 yr. With the shortage of steel relegating economic considerations to a status of secondary importance, however, some companies are utilizing this method of mitigation. It is hoped that developments in this field of endeavor will improve the economic picture. In the meanwhile every effort is being made to extend the life of tubing now in place through the duration of the national emergency.

Low Pressure Project

The second of the two problems, "Low Pressure Sweet Oil Corrosion," was first generally observed only two years ago. Fig. 6 illustrates the type of attack. Literally hundreds of holes developed in as little as nine months. Due to the rather strange conditions surrounding the initial observations, little thought was given to its potential seriousness. Instead, it was thought that some freak attack had occurred that would be isolated. As more and more reports of failures were made the seriousness of the

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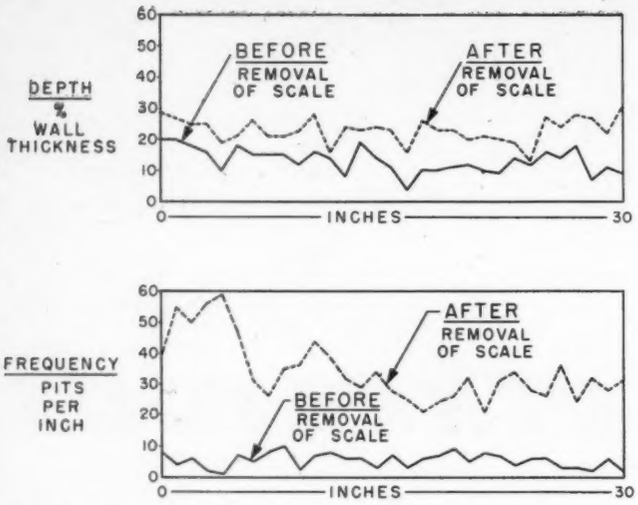


FIG. 3. Effect of scale removal on visual pit frequency and depth.

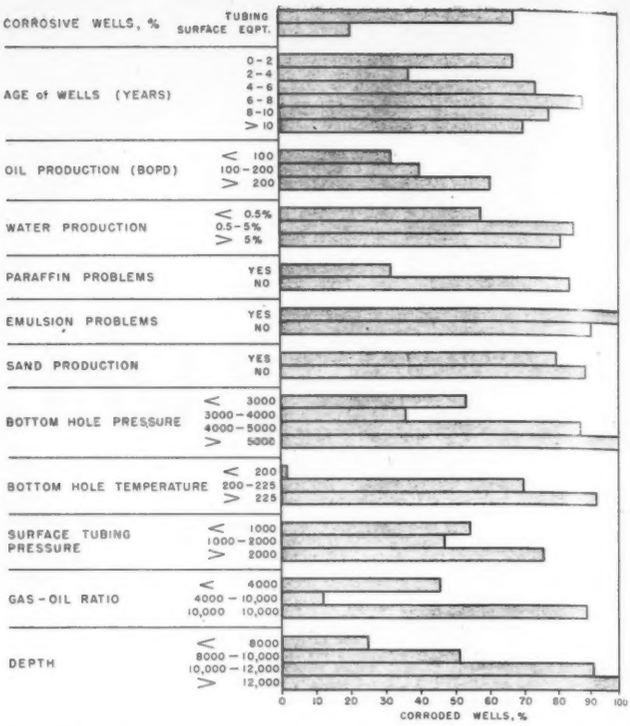
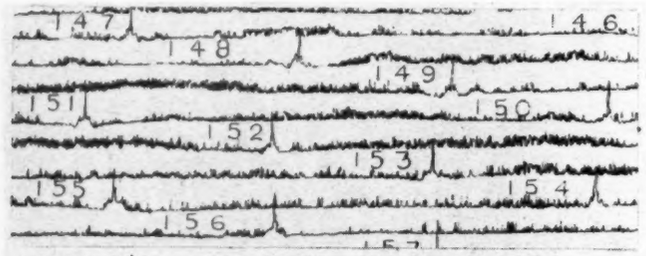


FIG. 4. Results of statistical study of corrosion in high pressure sweet oil wells. 359 wells reported.



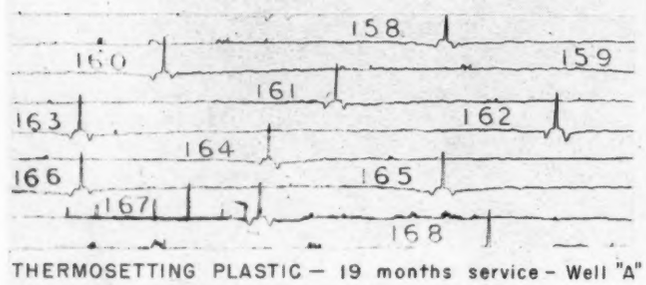


FIG. 5. Survey of pitting in three kinds of tubing.

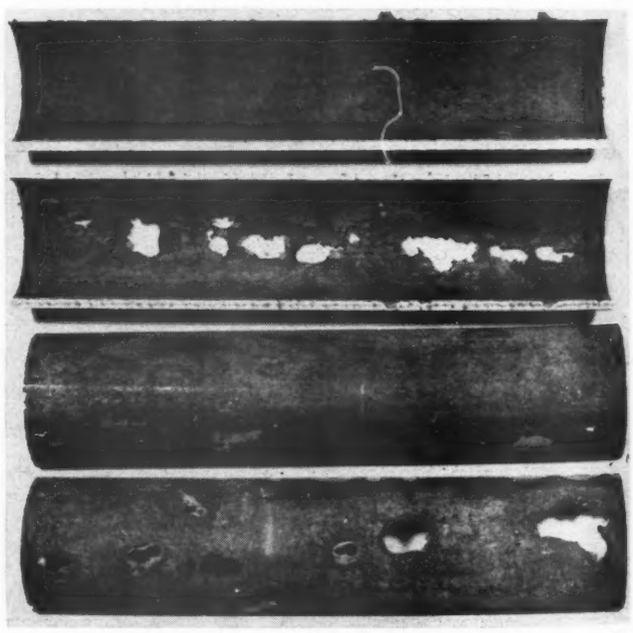


FIG. 6. Typical attack low pressure sweet oil well corrosion.

situation became alarming. The unique factor that characterized this phenomenon was essentially that wells produced 10 to 15 yr with no symptom of corrosion. After this period of trouble-free operation an unexplained change occurred that reduced the tubing life to two years or less in many instances. A preliminary survey conducted by the NACE TP-1 committee revealed that several companies were experiencing the same trouble in numerous sweet fields. It was acknowledged immediately that the magnitude of the problem warranted industry-wide consideration. Accordingly, the NACE committee TP-1C on "Sweet Oil Well Corrosion" undertook it as a major project.

To provide necessary statistical data as well as individual well data, a questionnaire was submitted to all companies participating in committee activities. The questionnnaire was composed of two parts. One dealt with the accumulation of factual data and personal comments related to various fields from a field standpoint. The second dealt with basic production data, corrosion history, and analytical information on individual wells. It is expected that all fields thought to fall into this category will be covered. To date questionnaires have been requested by various companies which account for about 150 fields.

For each field numerous individual well forms will be completed. It is in-

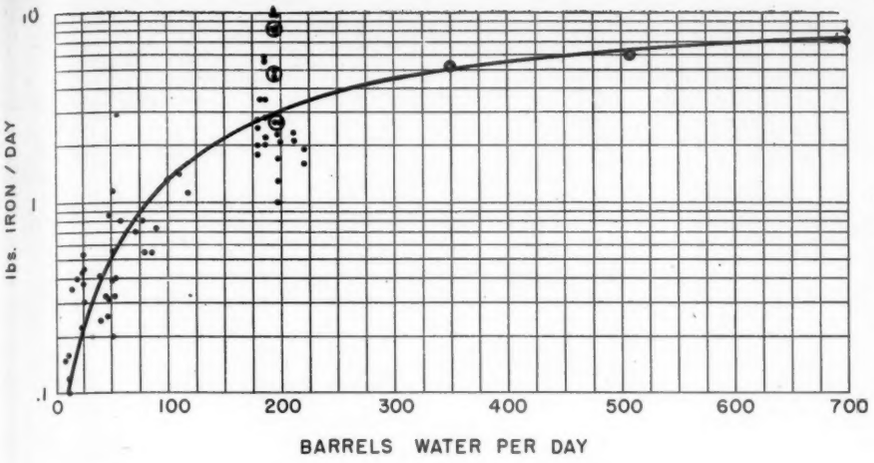


FIG. 7. Pattern for corrosion prediction—iron loss vs water produced.

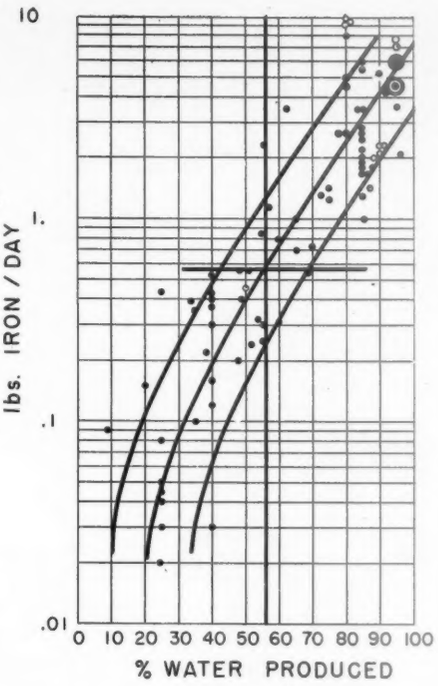


FIG. 8. Pattern for corrosion prediction—iron loss vs water per cent.

tended that within a field one well where no corrosion has yet been experienced will be reported for each corrosive well. To date approximately 1000 individual well forms have been distributed.

The purpose of this questionnaire was several fold. First, it was to define the magnitude of the problem; second, to exchange ideas pertaining to successful or unsuccessful remedial measures, and third, to develop criteria of corrosion.

Though sufficient time has not elapsed to allow complete return of these forms, it has been noted from preliminary data that:

1. Corrosion does not occur below some critical water-oil ratio.
2. The extent of corrosion after the critical value has been exceeded varies according to fluid velocity and total corrodent.
3. Gas-lift accelerates corrosive attack.
4. Organic acids are probably the most active corrosive agents. Carbon dioxide may also be significant.
5. Inhibitor injection is in general the most economical remedial measure.

As concerns remedial measures employed to date, the customary injection of organic inhibitors into an open annulus has afforded protection in many instances. Conditions existing in other locations render this technique valueless. For example, the inhibitor does not penetrate the high fluid level in many wells with the result that protection is not attained in lower zones.

This problem is being attacked in several ways. Water soluble inhibitors with a specific gravity greater than brines are being tested. Commonly available stick inhibitors have been lubricated down the tubing. This practice met with difficulties in wells where the bottom hole temperatures were too low to melt the binding material. Sticks that function independent of temperature have been developed and are being field tested.

Complete test results of various techniques will be forthcoming soon. It is anticipated that within a year successful remedial measures will be established for most conditions.

Relative to the significance of water-oil ratios, it is known that critical values will vary from field to field. Such a figure has been empirically established for several environments. In the United States all ratios to date have been greater than 50 per cent water. Very recently a value of 40 per cent was tentatively established for one field in Venezuela. Figs. 7 and 8 illustrate the effect of water production upon corrosion activity. Fig. 7 relates pounds of iron per day, which is a measure of corrosion activity, with barrels of water produced. It has been established empirically for wells approximately 5000 ft in depth that iron loss in excess of .5 lb per day is indicative of severe attack. Thus, these data show that for this particular field the critical quantity is reached at fifty barrels of water per day. Fig. 8 relates pounds of iron with per cent water. For this field the critical value is 55 per cent. Instances have been reported where cited critical values vary within a given well dependent upon producing equipment. In one field, for example, water percentages of 98 per cent can be tolerated on flowing wells with little effect, whereas, corrosion activity is severe when 70 per cent water is produced by gas-lift. These data, on the other hand, are contradicted by reports on other fields which show that severe attack takes places when little or no gas is used for lift purposes. The drop-size ratio is felt to provide a key to the explanation of discussed variations. If this relation can be established by compilation of empirical data on a sufficiently large number of wells, an important step toward accurately predicting corrosion will have been achieved. Production characteristics of a given well are usually available. Thus, if the relation of these values to an easily measured physical property, such as drop-size ratio, is known, it will be a simple matter to predict not only whether or not a given field is susceptible of attack; but, if so, an approximate date of initial corrosion activity can be anticipated. The ramifications of a pattern such as this are readily apparent. Prediction and control of corrosion can become a matter of applying known principles rather than the often used trial and error methods. Master control sheets (Fig. 7) can be maintained on wells in all fields where causative agents exist. Then, as the anticipated change-over from the dormant environment to the actively corrosive stage becomes imminent, a careful check of water analysis and coupon exposure tests can dictate remedial action. In this manner premature treatment of thousands of wells can be avoided without danger of costly failure.

The establishment of the aforementioned data is a tremendous task. The accumulation of information from several hundred corrosive and non-corrosive wells will be required. Such information will include:

1. Annual water production.
2. Annual oil production.
3. Injected gas-oil ratio.
4. Produced gas-oil ratio.
5. Corrosion history.
6. Well completion practices.
7. Water analysis.
8. Gas analysis.
9. Drop-size ratio.

Under the best conditions the collection of these data is difficult and it is almost impossible for any one company to accomplish it. With the thirty companies pooling their efforts through the Oil and Gas Production Committee of the NACE, it can be done with a minimum of effort and expense to any one organization. We hope to solve a major problem in one or two years that would at best require many years of work on the part of any one individual.

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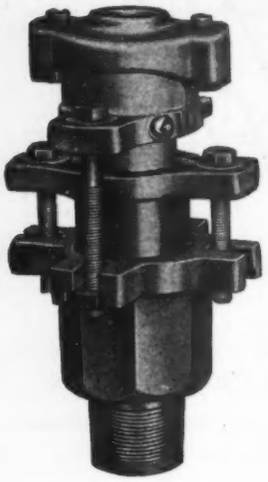
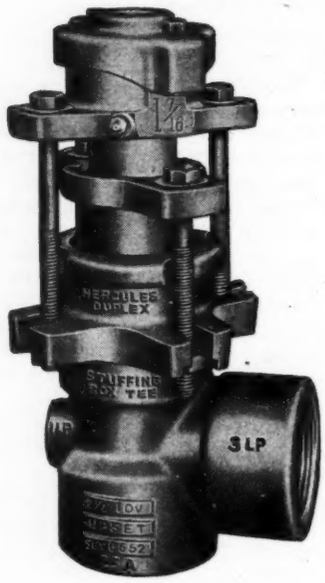
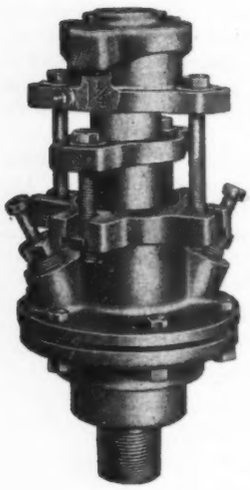


All Hercules Duplex Polished Rod Stuffing Boxes are Cone Packed for longest possible life and greatest economy. Illustrated (left) is Regular Type. Write for Bulletin 120-SB.

The Tee-Base Type Combination Stuffing Box and Tee (directly below) have been proven by years of service and savings to producers. Write for Bulletin 121-SBT.



A double packed Stuffing Box for use under most adverse pumping and flowing conditions (below). Be sure to order Type A-123-SBDP.



For greater savings, replace old style Upper Glands with the New Hercules Lubricating Upper Gland, as shown on Stuffing Boxes illustrated.

SOLD AT ALL SUPPLY STORES

Export Representative:
OIL FIELD EQUIPMENT CO., INC.
T. E. WARD, *President*
30 Church St., New York 7, N. Y.

HERCULES TOOL COMPANY
Manufacturers of Oil Field Equipment
General Office and Plant: 17th and Phoenix P. O. Box 286 — TULSA, OKLAHOMA — Telephone 3-1186 Cable Address "HERTOCO"

QUESTIONNAIRE
SWEET OIL WELL CORROSION - NACE COMMITTEE TP-1C
INDIVIDUAL WELL DATA

DATE
COMPANY
FIELD
FORMATION
DEPTH
WELL (CODE) B-6
GAS ANALYSIS:
1. PRODUCED GAS
CO_2 1.5 % ____ psi
2 INJ. GAS, IF ON GAS LIFT
CO_2 1.5 % 12 psi
O_2 0 % 0 psi
SOURCE RESIDUE GAS — PLANT
DEW POINT 85 °F

REMARKS:

WATER ANALYSIS

	DATE 10-20-44	DATE 1-16-47	DATE 7-10-49
% WATER	19	59	71
BOPD	27	27	24
TOTAL SOLIDS	206,306	204,028	206,823
IRON	58	83	109
SODIUM	55,236	53,155	55,601
CALCIUM	20,621	21,543	21,419
MAGNESIUM	2,054	2,349	2,028
SULFATES	216	185	146
CHLORIDES	127,833	126,770	129,429
CARBONATE	0	0	0
BICARB.	46	26	0
pH	5.4	4.8	3.6
SP. GR. @ 60°F	1.146	1.147	1.145
ORG. ACIDS	490	495	485
DROP SIZE			
RATIO			

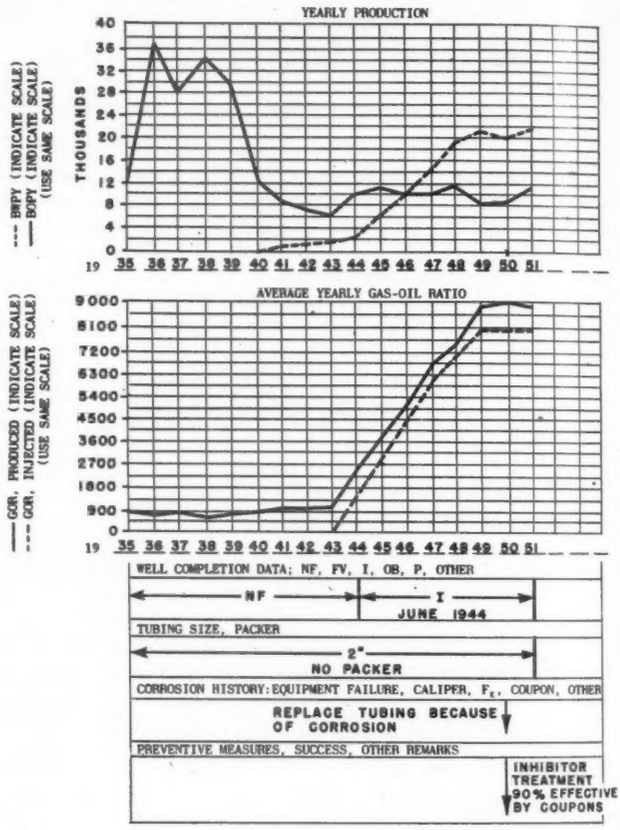


FIG. 9.

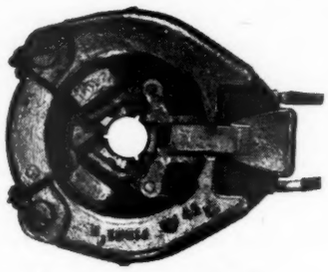
Conclusion

The sweet oil well corrosion projects discussed in this paper represent only two of the many costly corrosion problems in the petroleum industry. It is important that immediate consideration be given to the conservation of steel materials in these and other environments. In normal times corrosion prevention was justified solely upon economic considerations. The cost of study plus remedial costs had to be such that a significant profit over normal operations could be shown. In times of international tension such as we are undergoing today, however, where heavy defense programs greatly curtail metal for civilian consumption, we are being forced more and more to conserve the metals we have. Reduction of corrosion is the prime factor in this conservation. Effective control of corrosion can be achieved only by engineers trained in its technology. These engineers can do their best only if they solve their general problems cooperatively. The best forum with which to do this is the NACE. Management should and does recognize this opportunity and in most instances encourages their engineers to participate actively and freely in the association. This position was attained in the spirit of economic improvement of our industry, but today the conservation of metals is a requirement instead of an economic desirability. Thus, in defense programs the control of corrosion takes on new importance. We, as engineers, must do everything in our power to utilize to the fullest the materials at our disposal. ★ ★ ★

BJ MEDIUM WEIGHT POWER TUBING SPIDER

...puts more power to work for you!

BJ's new outstanding Power Tubing Spider is designed to give you faster, safer and more efficient operations on tubing jobs... *to put more power to work on your rig!*



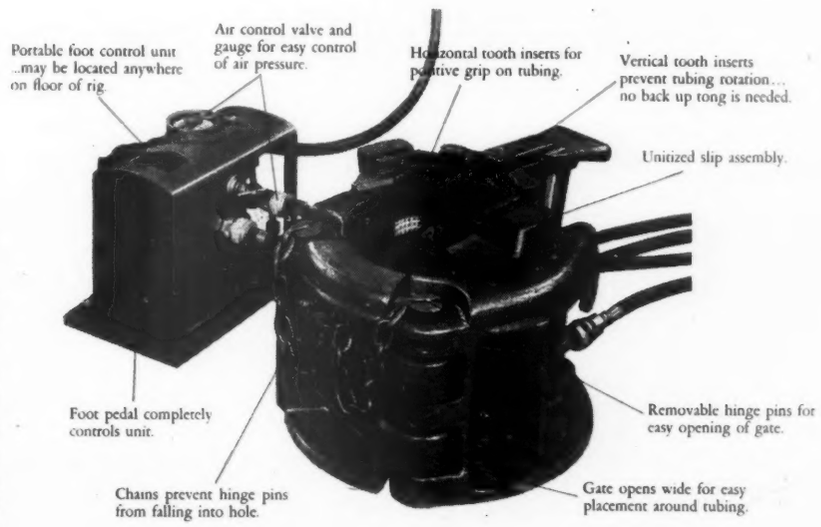
from the top...

from the side...

BJ POWER TUBING SPIDER IS *FASTER*...the entire operation of the spider is power controlled. A touch of the foot pedal and the slips are instantly *pressure* set or *pressure* raised.

BJ POWER TUBING SPIDER IS *SAFER*...dangerous hand setting of slips is eliminated. The foot control unit may be placed in any safe, convenient location on the floor of the rig...out of the way...ready for instant action...safe! Slips are set automatically if bumped by elevator...and cannot jump out or fall in the hole.

BJ POWER TUBING SPIDER IS *MORE EFFICIENT*...crews work better when they know they are working with a safe power tool. Increased safety and faster trips mean increased efficiency for your entire operation.


Portable foot control unit ...may be located anywhere on floor of rig.
Air control valve and gauge for easy control of air pressure.
Horizontal tooth inserts for positive grip on tubing.
Vertical tooth inserts prevent tubing rotation... no back up tong is needed.
Unitized slip assembly.
Foot pedal completely controls unit.
Chains prevent hinge pins from falling into hole.
Removable hinge pins for easy opening of gate.
Gate opens wide for easy placement around tubing.

Check the BJ Power Tubing Spider *from every angle*. You'll see the new vertical-tooth inserts which eliminate the need for back up tongs. Check the sturdy hinge pins with safety chains, and the wide angle gate which allows easy placement of the spider around the tubing. Watch the fast operation of the slips and the sure grip of the extra-long replaceable tooth inserts. Slips mechanically lock in up position while running the stand. There's no crimping or bottlenecking of tubing. From every angle you'll discover that for your rig you can't buy a better tubing spider than a BJ Power Tubing Spider.

...from every angle—you can't buy better than BJ!

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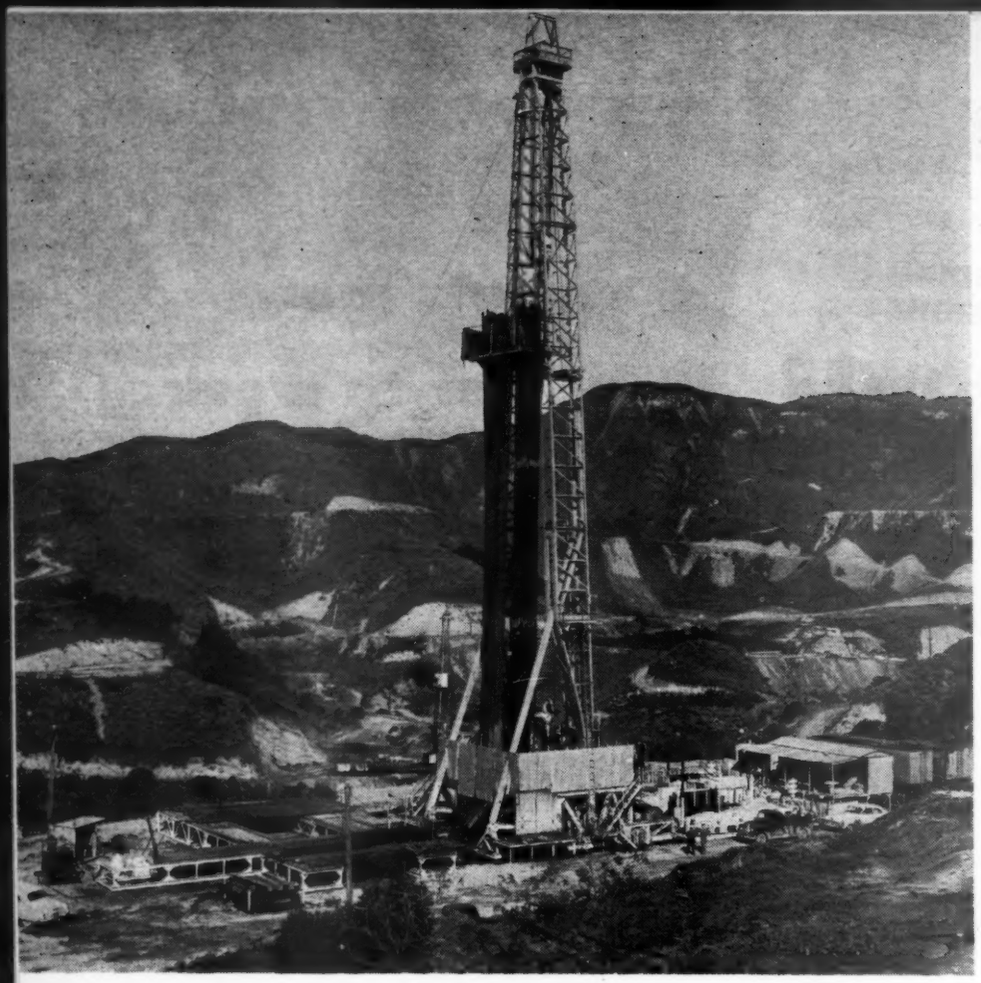
JOBBERS IN ALL PRINCIPAL OIL FIELDS

PB OIL FIELD & INDUSTRIAL SPECIALTIES



At left is package drilling rig. Overall view of Shell Oil Company's new rig on location in the Ventura Avenue field, California.

Package Drilling Rig

Shell's new mobile rig, placed in use at the Ventura Avenue field, saves time and cost in drilling

WILLIAM T. RINTOUL

A PACKAGE drilling rig designed by a major oil company to cut time and cost of drilling new wells is attracting considerable interest in the Ventura Avenue field near Ventura, California.

Shell Oil Company in cooperation with Ideco division of Dresser Equipment Company produced the heavy duty rig, which is being used by Shell for the development of oil sands below the 10,000-ft level in the Ventura Avenue field.

Engineers designed the package drilling rig to eliminate many of the hazards due to mechanical failure while drilling new wells, to facilitate tearing out and rigging up operations, and to shorten the time of moving between locations by providing a minimum number of packages to be transported from location to location.

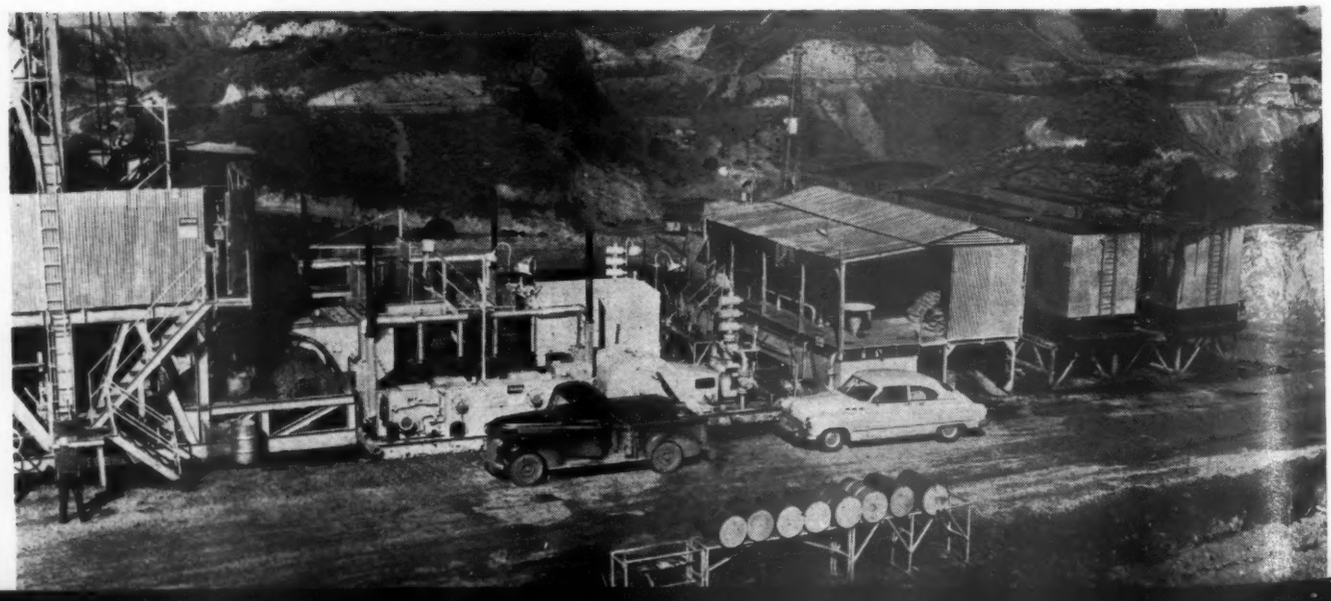
Currently on its third development well in the Ventura Avenue field, Shell's new rig has not yet recorded any shutdown time. Its two moves were accomplished at an appreciably reduced cost over that normally experienced in moving and rigging up a heavy duty unit.

Among features of the package drilling rig are pump-power packages, torque converter drives, chain-driven pumps, submerged drawworks, elevated catworks, double mud ditches, and dynamatic and hand-operated brakes.

No radical or untried equipment is contained in the package drilling rig. An Ideco Full-View mast is an integral part of the unit, which is the largest torque converter rig with 100 per cent friction-clutch operation ever placed in service.

The Ideco 1350-S drawworks and special torque converter transmission is designed to take advantage of the characteristics of torque converters and air clutches and permit clutch engagement

Below is power layout. Two identical pump-power packages, each equipped with two Hall-Scott V-12 gas engines, supply power for the rig.



High main bearing capacity

An Extra in Bethlehem Swivels at No Extra Cost

The only way to learn the *true rating* of a swivel is to check the main-bearing capacity. This rating is not always expressed by the manufacturer's symbol, the symbol he uses for catalog purposes. Example: one of Bethlehem's most popular swivels is known as the 150TA. This "150" does *not* mean the rating of the swivel. Actually, the main bearing has a capacity of 170 tons at 100 rpm. That's important. It's important to check the main bearing of any swivel before you buy. Otherwise, you may purchase a unit designated as "300 tons," only to find that the main-bearing capacity is as low as 150 tons at 100 rpm.

Each of the four Bethlehem swivels has high bearing capacity; high, that is, with relation to the size of the swivel. But there are other standout features, too—among them the double-life washpipe. By means of an ingenious device, the pipe can be locked at the top, so that the wear takes place at the bottom; or it can be locked at the bottom so that the wear takes place at the top. Thus the wear on both washpipe and packing can be divided, and the life of these parts prolonged—meaning *a big saving of costly shutdown time.*

There's a Bethlehem swivel for every drilling assignment, shallow or deep. Ask for full details, which will be furnished promptly.

In addition to its manufacturing plants and its sales and engineering service, Bethlehem Supply Company maintains stores throughout the Rocky Mountain, Midcontinent, Southwestern, and California oil fields. There are almost 50 of these modern, up-to-the-minute stores, all fully stocked to meet local day-by-day requirements.

FOUR SIZES OF BETHLEHEM SWIVELS

Catalog Number	Main bearing cap., 100 rpm
60TA	64 tons
100TA	123 tons
150TA	170 tons
300TA	302 tons

BETHLEHEM SUPPLY COMPANY

General Offices: 21 E. Second St., Tulsa, Okla.
West Coast Headquarters: Los Angeles, Calif.
Export Distributor: Bethlehem Steel Export Corporation
25 Broadway, New York, N. Y.
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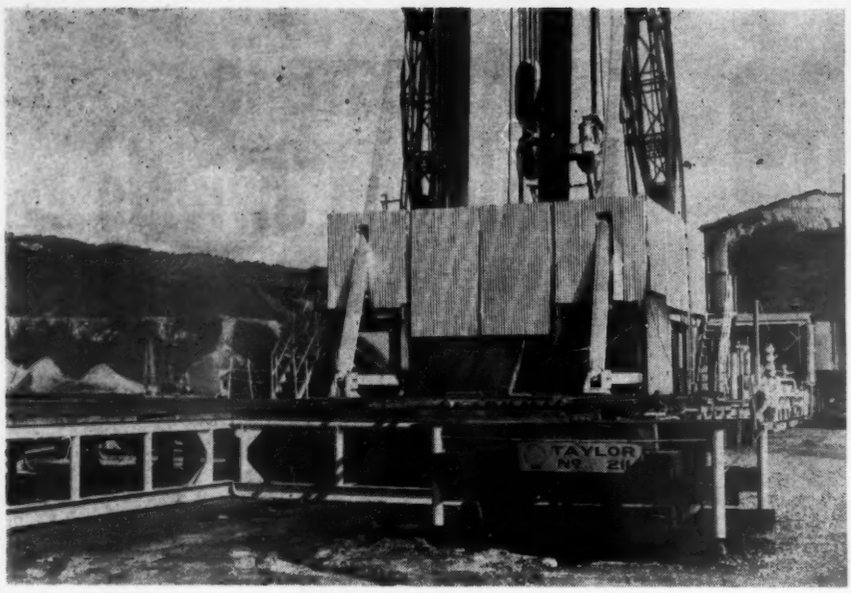
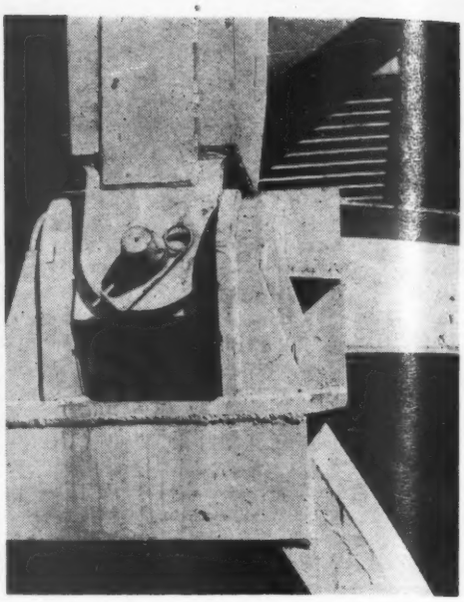
BETHLEHEM STEEL



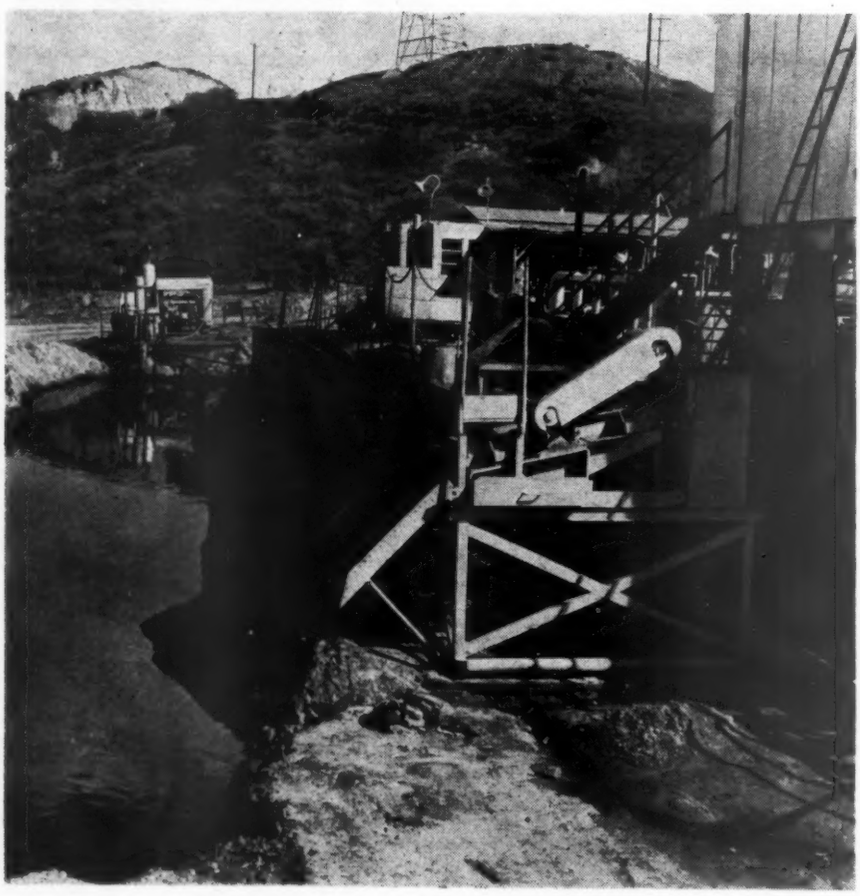
View of pipe rack in use at Shell Oil Company's package drilling rig in the Ventura Avenue field.



Tearing out and rigging up the substructure is facilitated by use of cotter keys and pins instead of bolts to secure diverse pieces of equipment.

to be made prior to advancement of the throttle. Thus the load may be accelerated with minimum wear and shock on clutches, chains, bearings, and shafts throughout the entire hoist, transmission, and compound. Three forward speeds and one reverse speed are contained in the transmission and all speed changes are made with air clutches. High and low clutches are mounted outboard for easy assembly. Intermediate speed clutches are mounted between bearings inside the transmission, but the clutch element is split and is replaceable in position without removing the shafts.

Shaker and ditches are shown. Shaker is equipped with two motors, one at each end.



Two identical pump-power packages supply the power for the rig. Each is equipped with two Hall-Scott V-12 gas engines that develop 425-hp at 1800 rpm. Special two-speed governors on the engines provide 1600 rpm for pump service and 1800 rpm engine speed for hoisting service. This selection is automatic by virtue of being linked to the pump clutch. When the clutch is engaged, the two engines automatically select the 1600 rpm setting. When the clutch is released, the governors return to an 1800 rpm setting.

Each engine is mounted independently on skids of 10-in.-wide flange beams arranged to be bolted directly to the skids of the engine compound. Tapered dowels maintain engine alignment.

When the drilling rig is moved, the engines may be left in operating position or removed to break down the load to conform to 8-ft road-width requirements. Output shafts of the compound are designed to accept the propeller shaft drive on either end, making the two power packages completely interchangeable. Each power package, consisting of two engines, compound and pump, is moved as a unit.

Each engine is equipped with a Torcon Model 19-ED torque converter and is coupled to the compound through Fawick air clutches. Air starters and Kittell silencers are also integral parts of engine equipment. Ross heavy duty heat exchangers are used to cool the torque converters.

Each two-engine and compound unit is equipped with a D-500 Emsco slush pump driven through an oil-bath-enclosed chain drive. All components are mounted on a heavy duty common skid. One set of engines can be used for both

It's better to work with

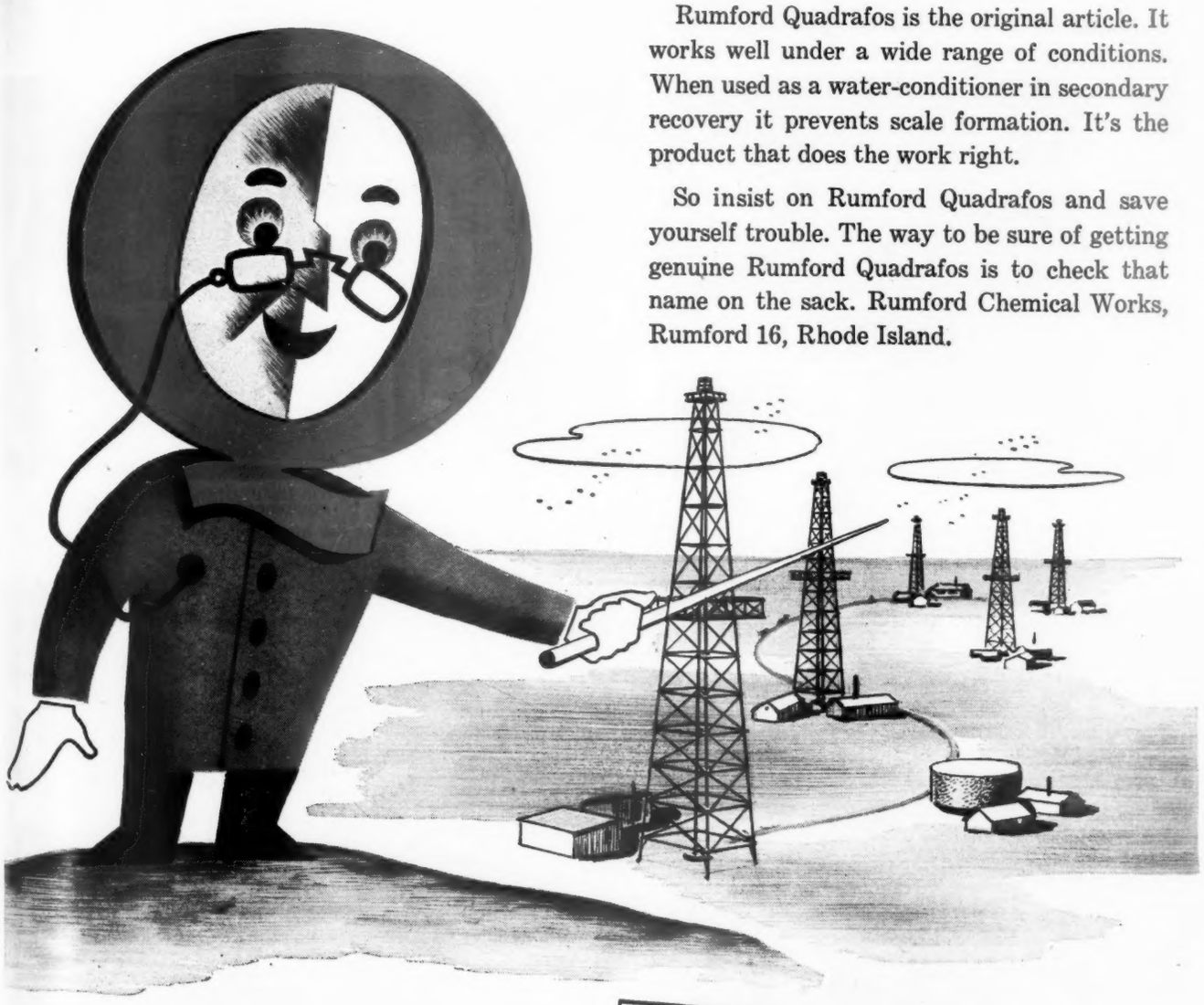
RUMFORD QUADRAFOS*

than to worry with a substitute

Every mud engineer, tool pusher and roughneck knows Quadrafos — what it will do, what to expect from it. Nobody wants a substitute — and nobody needs to take one.

Rumford Quadrafos is the original article. It works well under a wide range of conditions. When used as a water-conditioner in secondary recovery it prevents scale formation. It's the product that does the work right.

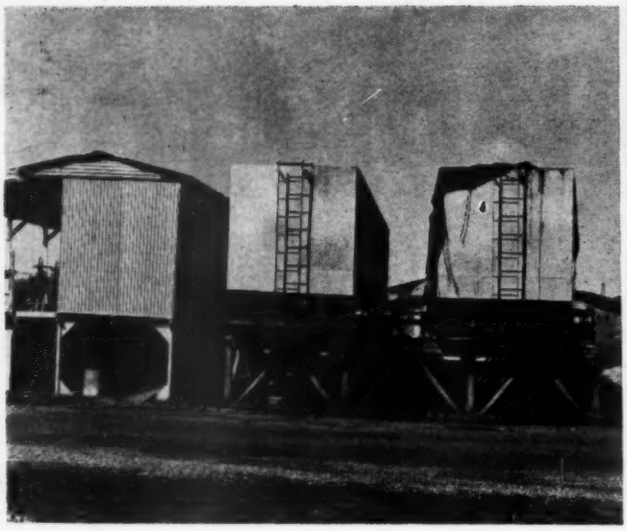
So insist on Rumford Quadrafos and save yourself trouble. The way to be sure of getting genuine Rumford Quadrafos is to check that name on the sack. Rumford Chemical Works, Rumford 16, Rhode Island.



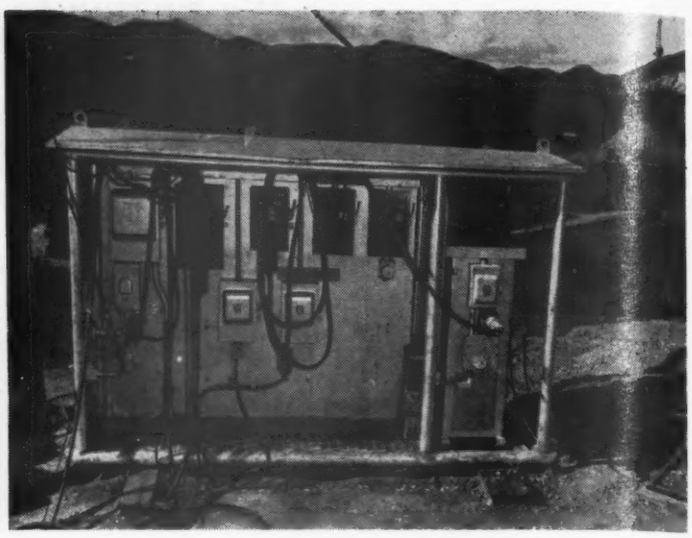
The "Old Reliable"...
First in the Field

ONLY WITH
QUADRAFOS
CAN WATER
DO SO MUCH, SO WELL

*Reg. U. S. Pat. Off.

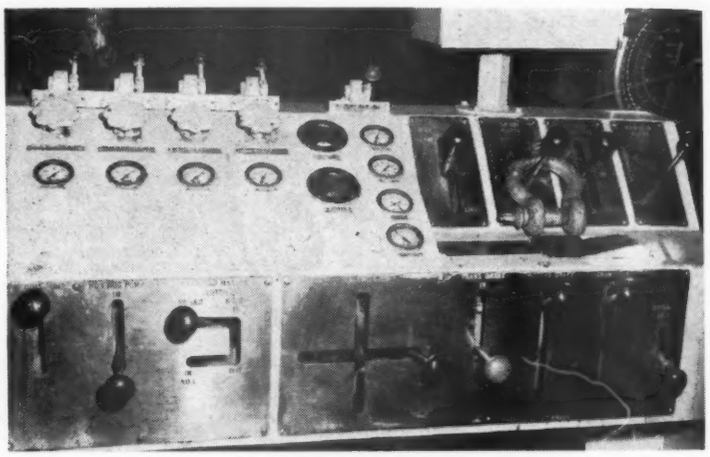


Two 375-bbl mud tanks are used by the package drilling rig.



Electric panel in use at Shell package drilling rig.

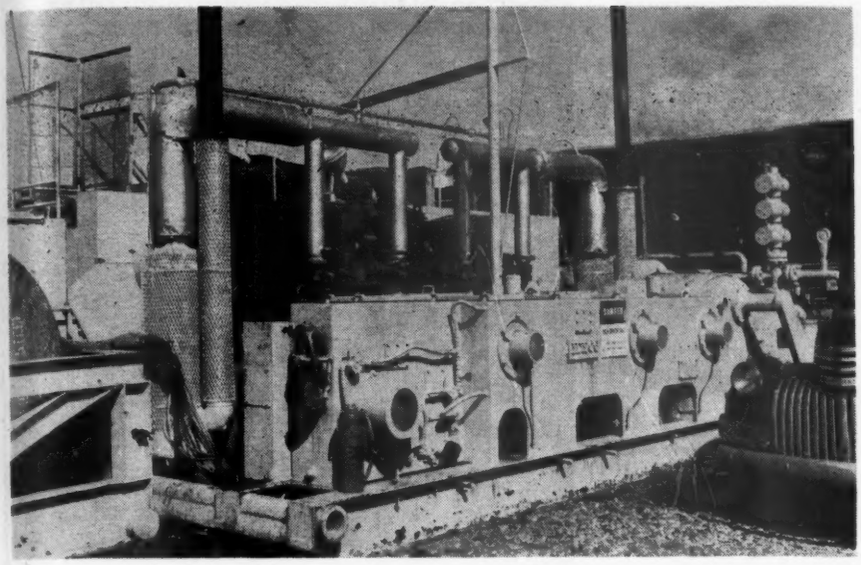
Controls are within easy reach of driller as he stands by console. Note comfortable doghouse opposite console.



Finger-tip control of virtually all equipment on the rig is provided by the modern console beside the brake on the derrick floor.

All major equipment except cathead has been placed below the derrick floor.

Double 70-foot mud ditch enables the rig to continue operating even if one of the ditches must be closed for cleaning-out.



Power Package — One of two pump-power packages that supply water for the rig.

pumps independent of the other set of engines, or both units can be compounded to the transmission, drawworks and rotary table.

In operation the two power packages are placed on opposite sides of a 40-ft-long transmission skid base and are connected to the transmission through universal-joint propeller shaft drives. Sliding alignment in the two universals that carry the drive to the drawworks has proved very satisfactory in the rig.

Grouping of all controls in a console cabinet near the brake on the derrick floor enables the driller to have finger-tip control on virtually all the equipment used in the package drilling rig. Controls most frequently used are positioned within easy reach of the driller as he stands at the modern console. From his position at the console, the driller has completely clear over-all vision of the floor and derrick. A small doghouse with electric heat is supplied for the comfort of the driller opposite the console.

A flush derrick floor area is provided by recessing the rotary table in the derrick floor. The floor looks comparatively empty because all major equipment except the cathead is below the floor. The catworks, a movable unit supported by the sub-structure spreader assemblies, is mounted on a skid assembly. The catworks consists of the catshaft and right-angled gear box with propeller shaft drive to the rotary table and attendant countershafting and enclosed chain drives.

A double reduction is used on the catshaft drive to permit the combination of low catshaft speeds and high drilling speeds. An inertia brake mounted on the catshaft in conjunction with the catshaft drive clutch gives single-lever control of both operations. Thus in an emergency only the inertia of the catshaft itself must be arrested.

A relatively high base—12 ft—permits use of adequate blowout preventers. A double hydraulic Shaffer unit and a Hydril unit serve as blowout preventers on the drilling rig.

Dynamatic and hydraulic brakes are cooled by an enclosed cooling tower below the floor of the derrick. Other equipment enclosed below the derrick floor includes a cellar pump, air compressor, air receiver, electrical switches, and casing line spool dock.

An advantage of the 70-ft-long, double mud ditches used by the drilling rig is the fact that the stream may be split to clean out either ditch without shutting down the rig.

Tearing out to move is facilitated by the use of pins instead of bolts to hold together equipment such as the substructure. The substructure can be readied for moving simply by removing several cotter keys and the pins they secure.

For moving, the rig is broken down into 11 loads. Each load is of a size that can be handled on a heavy duty truck or trailer. Loads are as follows: 1. mast; 2. and 3. two-piece box substructure; 4. catworks; 5. drawworks; 6. transmission; 7 and 8, compound units and pumps; 9. mud-mixing unit; 10 and 11. mud tanks.

According to overall design of the rig, all the heavy components are placed at ground level with the exception of the drawworks, which is raised four feet off the ground. * * *

QUOTES

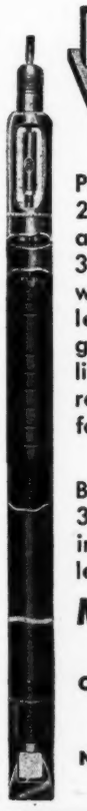
"Petroleum reserves, to be useful in an emergency, must be within reach of our industry and our military. Also, these reserves must previously have been developed to the point that they can be produced as required. To be dependent upon distant petroleum supplies would seem to be an invitation to disaster." — *J. Ed Warren, president, Independent Petroleum Association of America.*

STOPS FALLS!

Revolutionary New Type Safety Grating Eliminates Dangerous Walking Conditions . . . Guarantees Sure Footing.

In a recent test, shown above, a stock strip of Bustin Firm-Grip Grating was submerged in heavy chassis grease and then raised to a 15° slant. Even under those conditions, a man carrying a bulky box walked easily up and down the strip . . . maintaining perfect balance! Send for free Bustin booklet that shows industrial safety applications and specifications. Bustin Firm-Grip Grating Corp., 110 E. 130 St., New York 37, N. Y.

INCREASE PRODUCTION
Clean Out Better With



MILLER SAND PUMPS

Pump O. D. sizes are: 2½, 3, 3½, 4¼, 5, 5½ and 7 inches. 20, 25 and 30 ft. length. Strong bail welded to heavy seamless steel tube. Heavy grooved plunger assures liquid seal. Wire line direct connected to plunger for great suction.

MILLER BAILERS

Bailer O. D. sizes are: 3, 3½, 4¼, 5 and 5½ inches. 20, 25 and 30 ft. length.

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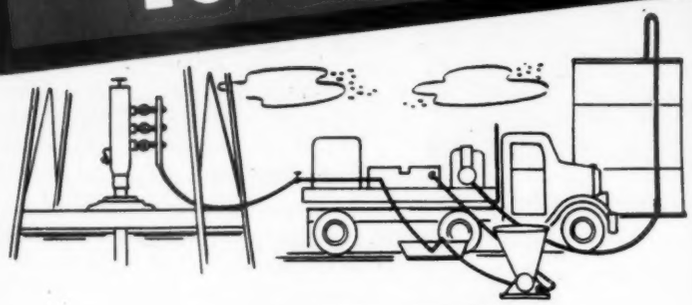
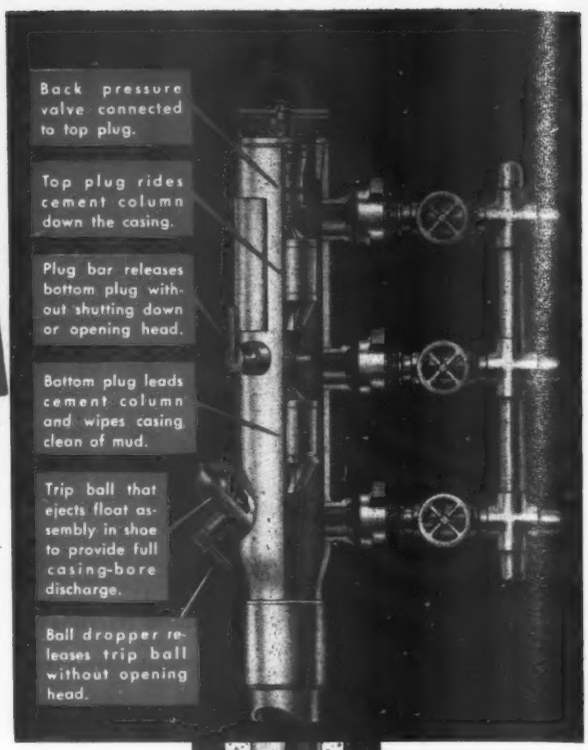
EXPORT OFFICE
30 Rockefeller Plaza
NEW YORK CITY 20, N. Y.
See Composite Catalogue Page 3365

From HEAD to SHOE




Back pressure valve connected to top plug.
Top plug rides cement column down the casing.
Plug bar releases bottom plug without shutting down or opening head.
Bottom plug leads cement column and wipes casing clean of mud.
Trip ball that ejects float assembly in shoe to provide full casing-bore discharge.
Ball dropper releases trip ball without opening head.

RECTOR FULBORE CEMENTING METHOD

Prevents Contamination of Cement

Hundreds of master cementing jobs by the Rector Fulbore Method prove the efficiency of its two plug method and the importance of its other exclusive features which are the basis of successful and satisfactory cementing jobs everytime. Ask your Rector Representative or authorized supply store for the complete story about better cementing with the Rector Fulbore Method.

PROTECTS AGAINST CONTAMINATION

The cement is completely and effectively segregated from well fluids by two closely fitting plugs which are positively and simply released at the proper time by mechanical means from outside the cementing head.

CLOSED CIRCUIT

Cementing head is never opened from the time cementing operations begin until they are completed. It is impossible for air pockets to form in either the mud or cement column.

FULL CASING DISCHARGE

Float assembly is pressure-ejected from the float shoe by the trip ball after casing string has been floated to position. This unrestricted opening reduces the load on the pumps . . . circulates greater volume with same pump pressure and results in higher velocity in space between casing and bottom of hole.

POSITIVE FLOW-BACK

When the back pressure valve, which has traveled down with the top plug, latches in the stall collar, it positively prevents flow-back of cement. Operator may bleed the pressure back to zero and leave the well open or close it in at final runnjng pressure.

RECTOR WELL EQUIPMENT COMPANY INC

★ MAKING THE OIL INDUSTRY SAFER

1100 NORTH COMMERCE ST. FORT WORTH, TEXAS

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REPRESENTATIVES IN ALL ACTIVE FIELDS

RECTORHEAD RECTOR FULBORE CEMENTING METHOD RECTORSEAL

Drilling Fluids Study on Gulf Coast Fields†

Oil emulsion mud increases drilling rates and at the same time reduces well costs

J. P. WEICHERT

THE most significant advancement in drilling fluids in the last few years has been the introduction of emulsified oil into practically all types of water base drilling fluids and, in so doing, has accomplished some rather outstanding results. The drilling rate of some formations has been doubled; bit life and time on bottom have been increased; rotary torque, pipe drag, and circulating pressure reduced. The high degree of hole lubrication provided by oil emulsion muds has made possible the trouble-free drilling of high angle directional holes; completion of difficult fishing jobs; the drilling of troublesome sloughing shale zones and reduction of hole enlargement. The productivity of tight, low pressure sands drilled with oil emulsion muds has been increased over that of similar sands drilled with conventional muds. Last, but not of least importance, the maintenance costs of weighted muds have been greatly reduced, resulting in lower over-all mud costs.

These advantages are obtained by using a mud that has the same general behavior and maintenance as the base drilling fluid from which it is prepared. No special methods of use or special rig equipment are required. No interference with the examination of cuttings or cores, or with electric logs is experienced.

An emulsion is an intimate mixture of two immiscible liquids, one being dispersed in the other in the form of fine droplets. Two types of emulsion can be formed when oil and water are mixed—the "water-in-oil" type in which the water phase is dispersed in the form of droplets in a continuous phase of oil, and the "oil-in-water" type in which the oil phase is dispersed in the form of droplets in a continuous phase of water. The oil emulsion muds that are in general use and those discussed in this paper are the "oil-in-water" type emulsions. A mixture of oil and water may be emulsified by violent agitation, but, upon standing, the droplets will coalesce to form two separate layers unless an emulsifying agent is present to stabilize the emulsion.

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The Author

J. P. Weichert is assistant zone superintendent of production for drilling in Zone 1, Texas, for Gulf Oil Corporation. A graduate of Rice Institute, with a BA degree in chemistry and two years post-graduate work, Weichert joined Gulf Oil as an engineer-trainee in the production division in 1936. He became a petroleum engineer (mud) in 1937, and worked throughout the Gulf Coast of Texas and Louisiana. In 1946 he became district petroleum engineer (mud) for the Gulf Coast district with headquarters in Houston, Texas, and received his present appointment in 1951.

There are many substances that will stabilize emulsions. These materials, however, can be classified in two general types: The soluble organic or chemical type and the solid type. Organic compounds, having a polar nonpolar type molecular structure—a portion of the molecule of this class being soluble in oil and a portion being soluble in water-concentrate at the interface between the oil and water forming a protective film around the oil. Finely powdered solids, as colloidal clay and silica, stabilize the oil droplets by forming a mechanically strong film around the globules to prevent their coalescence.

Tall oil soap is the most commonly used of the soluble organic emulsifiers in the present day oil emulsion drilling fluids. Bentonite, colloidal shale solids, silica, starch, carboxymethyl cellulose, lignitic compounds and lignosulfonates —one or more of which are present in the base drilling fluids—are prime examples of the finely dispersed solids.

The preparation of emulsion muds is a simple operation that usually does not result in any lost rig time. Pilot tests are run prior to the addition of the oil to determine the results to be expected. Then, 9 to 17 per cent by volume of oil

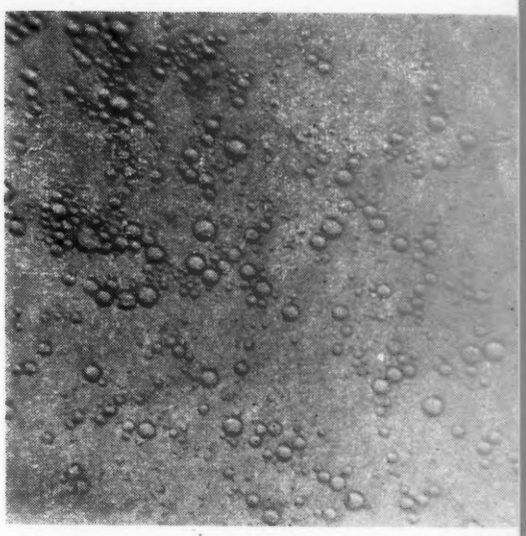

FIG. 1

—containing an emulsifying agent or with the emulsifying agent being added to the system simultaneously—is introduced slowly through the suction of the pump during one or two cycles of circulation. The resultant emulsion mud is subject to the same contaminants and responds to treatment in the same manner as the base mud from which it is prepared.

Crude, fuel oil, diesel oil, or a diesel oil blend containing a tall oil soap emulsifier may be added to the base muds to improve their performance characteristics. In drilling wells, a straight run diesel or diesel oil blend is used in order to avoid any contamination of side wall samples or of cores, which is possible with the use of crude oils.

The straight run diesels with, or without, a blended emulsifier are preferred for the following reasons:

1. Low gravity—from 28 to 38 API. The higher the gravity the greater the settling of the weighting material.
2. Low aromatic content or high aniline number (155 F or above), which reduces rubber deterioration to a minimum.

In general, 9 to 12 per cent oil is used for lubrication and improving the drilling rate, and a like percentage of a diesel oil blend containing a tall oil soap emulsifier is maintained to stop balling when soft shale formations are penetrated or when washing over stuck drill pipe where balling is apt to occur. Thirteen to 17 per cent of the diesel oil blend is used for the protection of sands or of sloughing shales.

Fig. 1 is a photomicrograph taken at 950 magnifications of an "oil-in-water" emulsion containing 2 per cent of the diesel oil blend. Note that the oil is dispersed in the form of stable droplets or spheres. The larger spheres of oil in this picture have a diameter of approximately one ten-thousandth of an inch. It is these small droplets of oil that account for the difference in the performance characteristics of the emulsion mud and the base mud from which it is prepared.

With these stabilized droplets thoroughly dispersed in the mud, it is not improbable that these spheres act like ball bearings between the plate-like clay particles, resulting in decreased friction — thus, accounting for the decrease pump pressures or increased circulating volume and the better lubricating properties of an emulsion mud.

When oil is introduced into a mud, the water loss is reduced in proportion to the amount of oil added. A reasonable explanation of this is that the stable droplets plug the capillary channels of the mud filter cake as filtration proceeds. This is supported by the fact that the filtrate of a stable emulsion is clear water.

Probably the most important factors contributed by the emulsified oil in mud is its ability to wet steel preferentially with a film of oil at points of intense rubbing and to coat shale cuttings. This is especially true of emulsion muds prepared with diesel oil containing a tall oil soap emulsifier. This oil film keeps the shale cuttings from sticking to the cutting edges of the bit, drill collars, and pipe, and reduces the disintegration of the shale cuttings being circulated from the well bore.

Thus, the four principal properties contributed by emulsified oil are:

1. Lubrication
2. Sealing of the wall cake.
3. Oil wetting of the steel.
4. Coating of the cuttings.

To determine the effect of oil emulsion mud upon drilling rate, bit life, and other bore hole problems, a field test was conducted in March 1949, at the Section 28 field, St. Martin Parish, Louisiana, because of the low rate of penetration and the large number of rock bits used. The Pellerin, et al No. 1, the test well, was compared to the Henry Melancon, et al No. 1, as they were both geologically on strike, drilled by the same rig and crews. Both wells were drilled with 9⅞-in. rock bits with the same number and size drill collars, the same weight on bit. The same type of 10.7 lb per gallon lightly treated phosphate mud was used in both, except for the maintenance of 11 to 17 per cent by volume emulsified oil in the test mud. The results and summary are given in Table 1.

In view of the favorable results obtained in the Pellerin well, emulsified oil was introduced into other wells in the Gulf Coast of Louisiana and Texas. Table 2 shows the results obtained on Delta Securities Company, Inc., No. 25 in the Bully Camp field, La Fourche Parish, Louisiana, when 15 per cent by volume of a diesel oil blend was added to a 15.2 lb per gallon lime-starch mud while drilling at 9008 ft. Drilling data are shown for the 500-ft interval before and after adding the oil. Examination of the cuttings and other geological information indicated the formations in the sections compared to be the same.

Emulsified oil was introduced in the Krotz Springs field, St. Landry Parish, Louisiana, primarily to check its effect upon hole enlargement and, secondly, for its effect upon drilling rate. Drilling data are given in Tables 3, 4, 5, and 6, and are for sections geologically comparable. Twelve and one-quarter inch rock bits were used on all wells shown.

There are several factors that influenced drill rate and are given as follows:

1. Weight on bit.
2. Fluid velocity and the pressure drop across the bit.
3. Speed of bit rotation.
4. Selection of bits.

These factors remained the same for all comparable wells shown in the preceding tables, with the exception that on two water base wells in Krotz Springs field there was from 2000 to 5000 lb more weight used on the bits. Yet, the introduction of emulsified oil has increased the drilling rate 17.4 to 115.2 per cent, and the feet per bit 55.5 to 149.0 per cent.

The advantages of emulsion muds in the drilling of directional holes is very apparent because of the large reduction in rotating torque and pipe drag, resulting from the lubricating properties of the emulsified oil. It is thought that there has been an improvement in drilling rate in most every directional hole that used emulsion mud. Comparisons are difficult, however, because of varying conditions in such operations.

Ten per cent diesel oil with a soap

TABLE 1. Section 28 field, St. Martin Parish, Louisiana.

Well and number	Type mud	Section drilled, ft	Footage	Bits used	Weight on bits	Ft/bit	Rotating hours	Bit time hours	Drilling rate Ft/hr
Melancon 1....	Water base	9428—10,423	995	15	3000	66.3	480.5	32	2.07
Pellerin 1.....	11-17% oil emulsion (Soap emulsifier)	9420—10,429	1009	8	3000	126.1	416.0	52.1	2.43

Summary of results
1. Saved 7 bits and trips — a reduction of 46.6 per cent.
2. Saved 64.5 rotating hours — 13.4 per cent.
3. Increased bit time 20.1 hr — 62.8 per cent.
4. Increased footage per bit — 59.8 ft — 90.5 per cent
5. Increased drilling rate 0.36 ft/hr — 17.4 per cent.
6. Saved 4.4 days rig-time at $1,019.48 per day = $4,485.72 plus $1,207.36 for bits.....=Total $5,693.08

TABLE 2. Bully Camp field, La Fourche Parish, Louisiana.

Well and number	Type mud	Section drilled, ft	Footage	Bits used	Weight on bits	Ft/bit	Rotating hours	Bit time hours	Drilling rate Ft/hr
Delta Sec. Co., Inc. 25.....	Lime-Starch	8462—9000	538	8	2000	67.3	211	26.4	2.55
Delta Sec. Co., Inc. 25.....	12-25% oil emulsion (Soap emulsifier)	9000—9500	500	3	2000	166.7	91	30.3	5.5

Summary of results
1. Saved 5 bits and trips — a reduction of 62.5 per cent.
2. Saved 120 rotating hours — 56,9 per cent
3. Increased bit time 3.9 hr — 14.8 per cent.
4. Increased footage per bit — 99.4 ft — 149.0 per cent.
5. Increased drilling rate 2.95 ft/hr — 115,7 per cent.
6. Saved 6.25 days rig-time at $1,666 per day = $10,412.50 plus $763.85 for bits.....= Total $11,176.35.

TABLE 3. Krotz Springs field, St. Landry Parish, Louisiana.

Well and number	Type mud	Section drilled, ft	Footage	Bits used	Weight on bits	Ft/bit	Rotating hours	Bit time hours	Drilling rate Ft/hr
Mertz "B" 2...	Water base	7189—9269	2080	14	14,000	148.6	240	17.1	8.67
Mertz "B" 3...	10% oil emulsion (Soap emulsifier)	7021—9018	1997	8	12,000	249.6	179	22.4	11.16

Summary of results
1. Saved 6 bits and trips — a reduction of 42.9 per cent.
2. Saved 61 rotating hours — 25.4 per cent.
3. Increased bit time 5.3 hr — 31.0 per cent.
4. Increased footage per bit — 101 ft — 68,0 per cent.
5. Increased drilling rate — 2.49 ft/hr — 27.6 per cent.
6. Saved 4.3 days rig-time at $1,004.28 per day = $4,318.40 plus $1,411,86 for bits.....= Total $5,730.26.

TABLE 4. Krotz Springs field, St. Landry Parish, Louisiana.

Well and number	Type mud	Section drilled, ft	Footage	Bits used	Weight on bits	Ft/bit	Rotating hours	Bit time hours	Drilling rate Ft/hr
Haas Hirsch "E" 4.....	Water base	6994—9400	2294	15	12,000	153	374	24.9	6.13
Mertz "B" 3...	10% oil emulsion (Soap emulsifier)	7021—9400	2379	10	12,000	237.9	228	22.8	10.8

Summary of results
1. Saved 5 bits and trips — a reduction of 33⅓ per cent.
2. Saved 146 rotating hours (over a longer interval)—39 per cent.
3. Reduced bit time 2,1 hr—8.4 per cent.
4. Increased footage per bit 84.9 ft — 55.5 per cent.
5. Increased drilling rate 4.67 ft/hr — 76.2 per cent.

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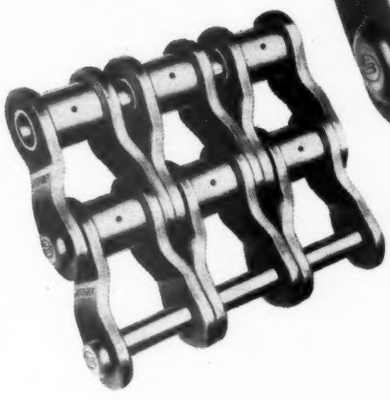

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TABLE 5. Krotz Springs field, St. Landry Parish, Louisiana.

Well and number	Type mud	Section drilled, ft	Footage	Bits used	Weight on bits	Ft/bit	Rotating hours	Bit time hours	Drilling rate Ft/hr
Haas Hirsch "E" 6.....	Water base	6867—9503	2636	16	16,000	164.8	330	20.6	7.99
Haas Hirsch "E" 8.....	9 to 12% emulsion (Solids emulsifier)	6778—9420	2642	10	11,000	264.2	224	22.4	11.79

Summary of results
1. Saved 6 bits and trips — a reduction of 37.5 per cent.
2. Saved 106 rotating hours — 32.1 per cent.
3. Increased bit time 1.8 hr — 8.7 per cent.
4. Increased footage per bit 99.4 ft — 60.3 per cent.
5. Increased drilling rate 3.80 ft/hr — 47.6 per cent.
6. Saved 6 rig days at $1,004.28 per day = $6,025.68 plus $1,411.86 for bits.... = Total $7,437.54.

TABLE 6. Krotz Springs field, St. Landry Parish, Louisiana.

Well and number	Type mud	Section drilled, ft	Footage	Bits used	Weight on bits	Ft/bit	Rotating hours	Bit time hours	Drilling rate Ft/hr
Merts "B" 2...	Water base	6996—9269	2273	15	14,000	151.5	263	17.5	8.64
Joy Law'c);"D" Merts Sand Unit Well 1..	9 to 12% oil emulsion (solids)	7065—9467	2402	9	12,000	266.9	150	16.7	16.01

Summary of results
1. Saved 6 bits and trips — a reduction of 40 per cent.
2. Saved 113 + rotating hours—43 per cent.
3. Decreased bit time 0.8 hr — 4.57 per cent.
4. Increased footage per bit—115.4 ft — 76.2 per cent.
5. Increased drilling rate 7.37 ft/hr — 85.3 per cent.
6. Saved 6.21 days rig-time at $1,004.28 per day = $6,236.58 plus $1,411.86 for bits..... = Total $7,648.44.

emulsifier was introduced into a 10.7 lb natural mud on LaFourche Levee district—State Unit No. 22, Lake Hermitage field, Louisiana, at 6158 ft in the directional hole. The torque was reduced from 150 to 50 lb on the torque pressure gage and the pipe drag reduced from 30,000 to 8000 lb.

Because of the reduction in rotating torque and hole friction that has been observed during the use of oil emulsion muds, we have made it a practice to add emulsified oil to all directional drill operations. Since this practice has been followed, trouble has been reduced to a minimum.

As a possible explanation, the following reasons are advanced:

1. Reduction of torque and hole friction so that the actual weight on the bit is more accurately shown by the weight indicator.

2. The oil wetting of the steel prevents the balling or clogging of the cutting edges of the bit so that a new penetration or cut of virgin formation is made with each rotation of the bit.

3. The oil film on the steel increases the bit life by improving the lubrication of the bearings and decreasing the formational wear on the cutting edges of the bit.

As the overall cost of a well is influenced by the mud cost as well as drilling time, especially where high mud weights are maintained, a study of the effect of the emulsified oil upon maintenance and overall mud costs was undertaken. Although the study is incomplete, some of the results are shown in Table 7.

From these data, it may be seen that the maintenance cost of a 10.1 to 10.3-lb oil emulsion mud is the same or slightly less than that of the base mud from which it is prepared and that the overall mud cost is higher by an amount slightly less than that of the cost of make-up of the emulsion mud. Thus, it takes a saving of 1.75 days rig-time for a land rig and approximately 1 day for a barge rig, to pay for this extra cost. Upon examination of the drilling rate data of Tables 1 through 6, it becomes apparent that a profit of 2.5 to 5.25 rig days resulted from the use of emulsified oil in the mud.

The data for the 14.8 to 15.2-lb lime starch emulsions containing a soap emulsifier show a reduction in maintenance cost of 58 per cent in overall mud cost of 21.7 per cent over that for the same weight lime-starch mud. Whereas the lime-starch emulsion using solids as the emulsifier, reduced the maintenance cost by only 16.1 per cent and the overall cost by 8.9 per cent. Thus, showing the oil emulsion with soap emulsifier to be the more efficient of the two. The above indicates that the addition of emulsified oil results in a lower maintenance cost for weighted muds and in some cases reduces the overall mud cost for the well.

A possible explanation lies in the fact that a cleaner bit is maintained with the emulsion mud, resulting in less grinding of the formation solids into the mud. The shale cuttings are coated with oil, which retards their disintegration while being circulated to the surface. If the above two factors are true, there will be fewer particles of shale sufficiently small to pass through the screen of a shale shaker, and to be jetted into the mud by the pump and subsequent action at the nozzles of the bit.

So far in this discussion, it has been shown that emulsion mud definitely influences the drilling rate, bit life, and total mud cost where weighted muds are used. These factors are important but there are other problems related to drilling which at times may assume proportions of even more importance. Drilling rate, etc., means little during times when a hole is giving trouble due to sloughing shale, severe balling, and other causes that result in lost time and, sometimes, stuck drill pipe. Emulsion mud is not a cure-all, but experience has shown it to be very helpful in handling a variety of troublesome hole problems.

Numerous cases of sloughing shale have been corrected by the use of emulsion muds. It is thought that this can be attributed to the low filtration properties of the emulsion mud and the sealing of the walls of the hole by the droplets of oil, which retards water-soaking of the formation drilled: It is probable that the same factors that contribute to hole enlargement are often the cause of sloughing shale troubles.

The reduction in hole enlargement by oil emulsion muds was noticed first in the Goose Creek field, Harris County, Texas. Fig. 2 shows caliper logs of the 1400 to 2700-ft intervals of the Hirsch

TABLE 7. Comparative costs between oil emulsion muds and water base muds.

Well and number	Section drilled, ft	Feet	Size hole, in	Type mud	Mud wt, lb	Over all mud cost	Maintenance cost	Footage maint, ft	Maintenance cost/ft	Over all cost/ft
Haas & Hirsch "E" 7.....	6819—9600	2781	12¼	Water base	10.3	....	$2540	2781	$0.91	$.....
Krotz Springs, La., Merts "B" 2.....	6722—9741	3019	12¼	Water base	10.3	....	2567	3019	0.85	.....
Krotz Springs Merts "B" 3.....	6874—9737	2863	12¼	10 % emulsion (Soap emulsifier)	10.3	$4423	2486	2863	0.87	$ 1.58
Krotz Springs.....										
La. State "QQ" 52, Grand Bay, (Original Hole).....	5902—7602	1700	9⅞	Water base..	10.1	....	428	1700	0.25	.....
La. State "QQ" 52, Grand Bay (Directional)	5895—7602	1707	9⅞	8 to 12% emulsion (Soap emulsifier)	10.1	2140	356	1707	0.21	1.25
Haas & Hirsch "E" 6, Krotz Springs.....	9500—11,000	1500	8½	Lime-Starch	14.8	15,503	6024	857	7.03	10.34
Haas & Hirsch "E" 7, Krotz Springs.....	9600—11,000	1400	8½	Lime-Starch emulsion (Solid)	15.1	12,918	....	....	....	9.23
Merts "B" 2, Krotz Springs.....	9736—11,000	1264	8½	Lime-Starch emulsion (Solid)	14.8	12,273	2355	399	5.90	9.71
Merts "B" 3, Krotz Springs.....	9800—11,200	1400	8½	Lime-Starch emulsion (Soap emulsifier)	14.8	11,334	4191	1376	3.05	8.10
Delta Sec. Co., Inc. 25, Bully Camp, La....	8713—9000	287	8½	Lime-Starch	15.2	....	3280	28	7.15	.....
Delta Sec. Co., Inc. 25, Bully Camp, La....	9008—9500	492	8½	Lime-Starch emulsion (Soap emulsifier)	15.2	5001	122	492	2.99	.....

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FIG. 2. Caliper log of comparable holes, Goose Creek, Texas

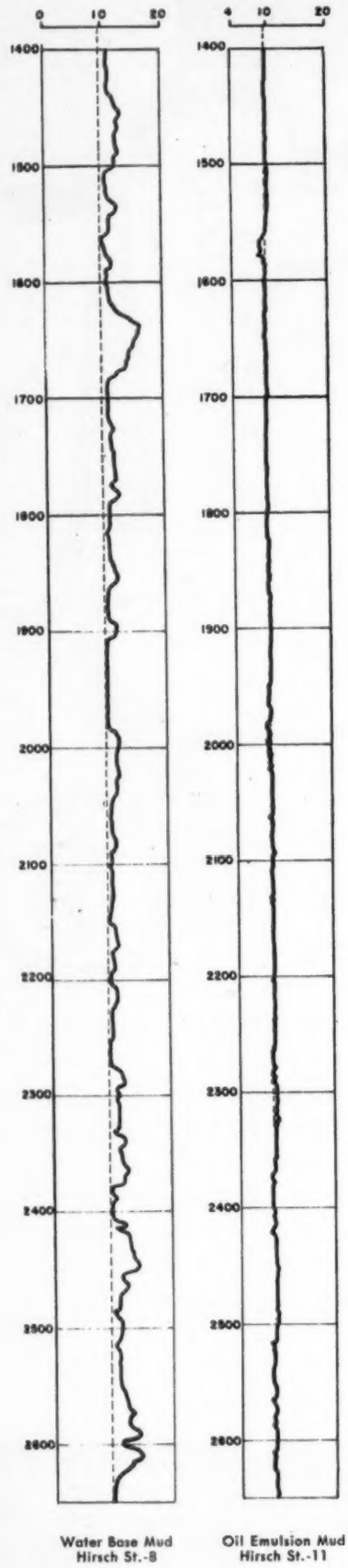


FIG. 3. Caliper log of comparable holes, Krotz Springs Field, Louisiana

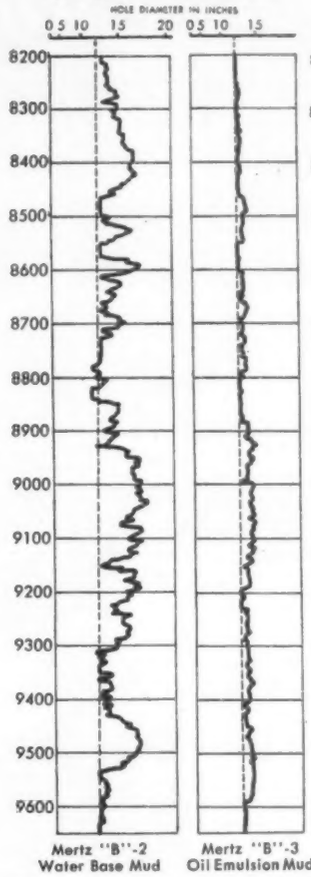


FIG. 4. Caliper log of comparable holes, Krotz Springs Field, Louisiana

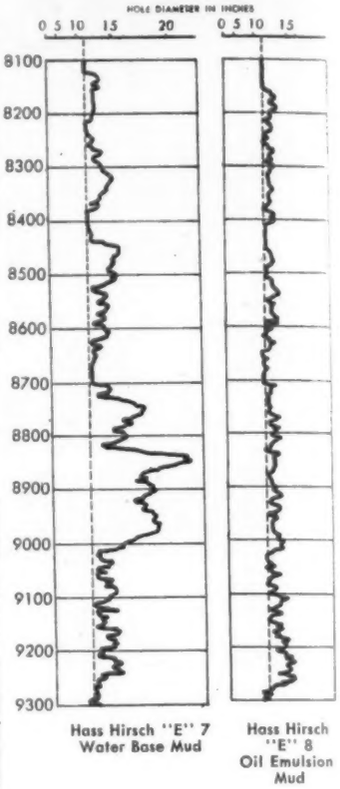


FIG. 5. Caliper logs of original and sidetracked holes, Quarantine Bay Field, Louisiana, Louisiana State 00-73

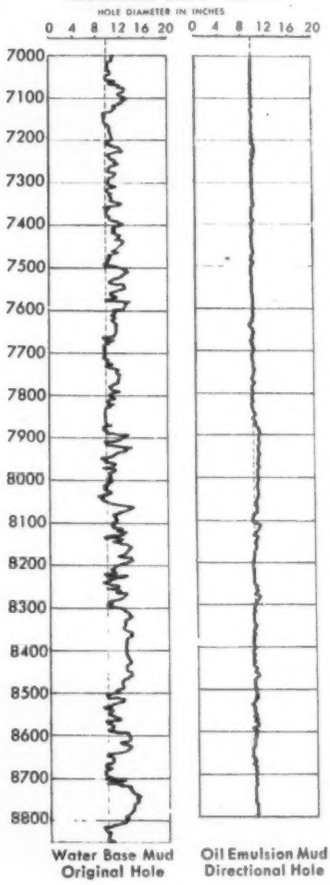
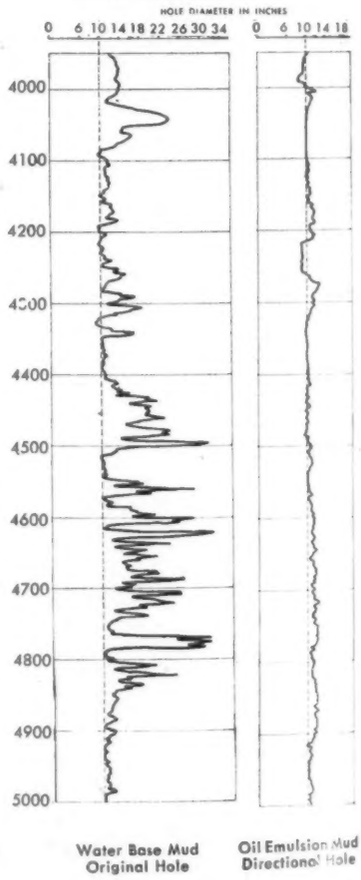


FIG. 6. Caliper logs of original and sidetracked holes, Moore Field, Texas
J. M. Moore No. 74



State No. 8 drilled with a lightly treated phosphate mud and of Hirsch State No. 11 drilled with the same type mud containing 12 per cent emulsified oil (soap emulsifier). The protective effect of the emulsion mud is shown by the bit size hole in Hirsch State No. 11, whereas, the hole in Hirsch State No. 8 is considerably enlarged. This reduction in hole enlargement has held true for the 31 wells drilled with emulsion mud in this field.

In order to verify this effect at a greater depth, the Krotz Springs field, St. Landry Parish, Louisiana, was chosen because of the large washouts that occurred throughout the shale sections above and below the productive sands.

Fig. 3 shows the caliper logs of the sections 8200 to 9650 ft. In the Harriet Mertz "B" No. 2, phosphate-treated mud, the measured hole enlargement over the bit size of 12¼-in. is 87 bbl, or 41 per cent. Harriet Mertz "B" No. 3, 10 per cent oil emulsion (soap emulsifier), shows an increase in volume of only 30 bbl, or 13.7 per cent.

Comparable calipers of the sections 8100 to 9300 ft is shown in Fig. 4. In Haas and Hirsch "E" No. 7, water base mud, the hole enlargement is 56 bbl, or 31.9 per cent, while in Haas and Hirsch "E" No. 8, using 8 to 12 per cent oil solids type emulsion, there is an increase of 11 bbl, or 6.4 per cent.

Fig. 5 shows the calipered sections of the original hole and the directionally drilled hole of Louisiana State "QQ" No. 73 in the Quarantine Bay field, Louisiana. In the original hole, the depths have been corrected to show the same sections encountered in the directional well. The first hole, drilled with a water base mud, shows an enlargement over that for the 9⅞-in. bit size hole of 90.5 bbl, or 53 per cent. Whereas the directionally drilled hole, drilled with a 10 per cent oil chemical type emulsion shows a negligible amount of enlargement.

The caliper logs of the original hole and of the directional hole in J. M. Moore No. 74, Moore's field, Fort Bend County, Texas, are shown in Fig. 6 for the sections 3950 to 5000 ft. The original hole, water base mud, shows an increase in volume of the 9⅞-in. bit size of 66 bbl, or 66 per cent. The directional hole, using 15 per cent oil emulsion with a soap emulsifier, showed an increase of 11 bbl, or 11.5 per cent.

From the above figures and data, the effectiveness of the oil emulsion muds in reducing hole enlargement is demonstrated very aptly. Thus, reducing to a minimum shale troubles, key-seating whether in a straight or directional hole, volume of fluid to be circulated and treated, the volume and placement of cement.

The balling of shale on the bit, drill collars and pipe, at times presents a very severe drilling problem. It may cause the loss of considerable time due to reaming and, in extreme cases, to sticking of the drill pipe. Shale balling results in a restriction of the annulus which in some cases is a major contributing factor to the loss of circulation.

Having observed the effect of oil emulsion mud in preventing the balling or clogging of the cutting edges on the bit, it was decided to apply this effect where severe balling on drill collars and pipe had occurred. The opportunity presented itself in October, 1949, in the Goose Creek field, Texas. Nine per cent by volume of crude oil was added to the lime-starch mud containing 25,000 ppm salt and a 400 ppm Calcium on Gaillard Fee No. 24, with the results that 90 per cent of the balling was eliminated. This volume of crude oil was introduced a few days later into the same type mud on Beaumont Petroleum Company State No. 47 with a resultant reduction of only 40 per cent in the balling. This difference in effect between the two wells was attributed to the 25 per cent greater annular velocity of the fluid on Gaillard Fee No. 24.

Severe balling was experienced on our E. R. Taylor, et al No. 60, Pierce Junction field, Harris County, Texas, while drilling below 6000 ft with a 15.0-lb lime-starch mud. Ten per cent by volume diesel oil was introduced to form a solids type emulsion in order to prevent this balling. The balling continued, however, and resulted in the sticking of the drill pipe at 7000 ft. It was decided to convert the mud to the chemical type emulsion because of its ability to oil-wet

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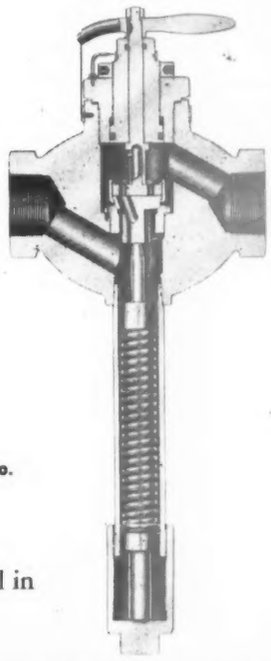

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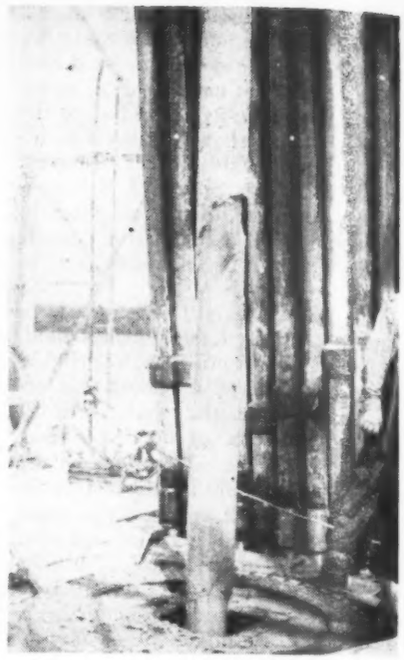

B

FIG. 7

the pipe. The well was sidetracked and drilled through the same section to a total depth of 1600 ft below that at which the pipe stuck. This was accomplished with only occasional balling on the walls of the hole and with none on the drill pipe.

The two pictures in Fig. 7 show the severe balling conditions that have been experienced in drilling the soft heaving shale zone in the Peach Point field, Barzoria County, Texas, with the silicate-brine mud.

From these pictures, it may be seen that the ball on the drill collars is as large as the bit and that the drill pipe in the background shows evidence of the balled shale (which has been scraped off) that formed above practically every tool joint running in open hole. Balling such as this has been a serious problem in this field.

In view of the success in preventing balling in the well at Pierce Junction, 10 per cent by volume of a diesel oil containing a soap emulsifier was added to the silicate-brine mud at 7452 ft in the J. F. Perry et al Unit No. 1. The well was drilled to 10,529 ft (3077 ft) with no balling occurring. The elimination of balling reduced the drilling time for this interval 9 days and saved 8 bits and trips. The mud cost for this interval in S. S. Perry No. 2 was $30,126 as compared to $17,393 on J. F. Perry et al Unit No. 1—a saving of $12,723.

After setting 7-in. casing at 10,529 ft, the mud was changed to a 16.7-lb lime-starch chemical type emulsion with 10 per cent oil. The hole was drilled and cored to 11,560 ft without any balling or loss of circulation and at a mud cost of $15,781 for this interval. On S. S. Perry No. 2, the mud cost for the interval of 10,728 ft to 11,095 ft was $55,418 with a 17.4-lb silicate-brine mud. The primary reason for this excessive cost was the many occurrences of lost circulation. The interval 11,095 to 11,532 ft was drilled with a 16.7-lb silicate-brine mud at a cost of only $12,930 with one loss occurring when the mud was weighted to 17.0-lb and then lowered to 16.7-lb to stop the loss.

Balling occurred on our Gay Union Corporation No. 1, Bayou Choctaw field, Louisiana, in a lime-starch solids type emulsion and was eliminated by conversion to the chemical type emulsion.

The consensus is that oil emulsion muds have no effect upon electrical surveys and little or no effect upon sidewall samples, and cores, conventional or wireline. The one exception to this was on Provost-Cyr Unit No. 1, Weeks Island field, Louisiana, in which the sidewall samples were contaminated with crude oil that was being used in the mud. For that reason, diesel oil or diesel oil blended with an emulsifier are now being used for emulsion muds.

In conclusion — our experience to date shows that oil emulsion muds have assisted in overcoming many drilling problems and have increased the rate of drilling. It does appear that the addition of properly emulsified oil to drilling mud offers a means of effecting economies in the drilling and completing of oil wells.

Acknowledgment

Much of the material in this paper was taken from: "The Effect of Oil Emulsion Mud on Drilling," by J. P. Weichert and Orien W. Van Dyke. A paper presented at the tenth annual meeting of Oilwell Drilling Contractors, at Tulsa, Oklahoma, October 9-10, 1950.

* * *

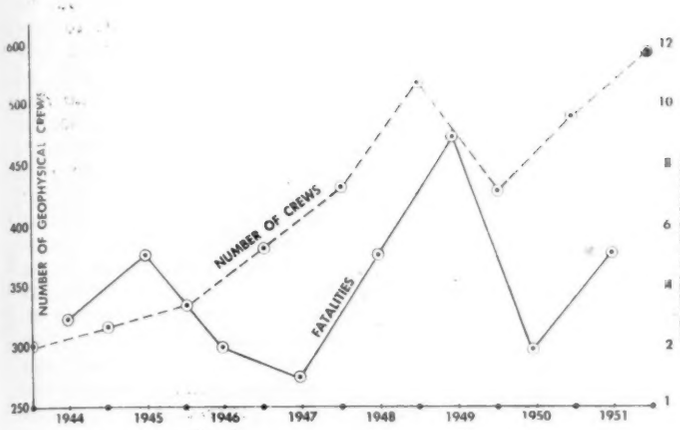

FIG. 1. Fatalities in oil exploration.

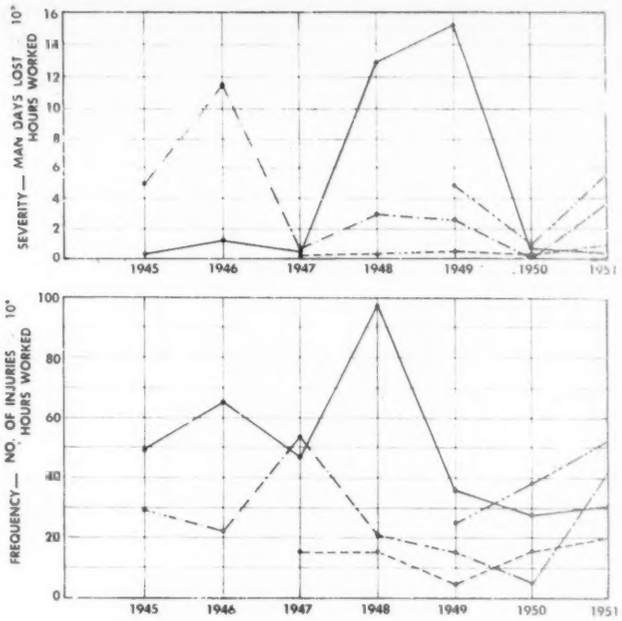

FIG. 2. Accident frequency and severity rates. (Each line is separate company.)

SAFE OPERATIONS—

A Challenge to the Geophysical Industry†

BART W. SORGE*

At least five people were killed during 1951 in oil exploration activities in the United States. The actual number of people killed during the year may be as large as 10, due to the fact that less than one half of our industry reports its accident experience to the recognized safety agencies, the American Petroleum Institute, the Bureau of Mines, and the National Safety Council. The majority of the workers who lost their lives need not have been killed had elementary safety precautions been observed. These recorded deaths represent a 150 per cent increase in fatalities over those experienced in 1950. In addition, the safety performance of the majority of geophysical operators, as shown on Fig. 2, was worse in 1951 than in 1950. Also, the accident statistics for oil exploration, as reported by the American Petroleum Institute, were more than twice as bad during 1951 as in 1950. The frequency rate, that is the number of lost-time personal injury accidents per million man hours worked, changed from 11.44 to 23.52, and the severity rate, that is the number of man days lost per 1000 hours worked, changed from .96 to 1.47. It appears still to be true that whenever an industry expands rapidly its safety record suffers. Fig. 1 shows this trend for geophysical exploration. The figures on the number of geophysical crews in the United States have been obtained from the annual report of the Committee on Geophysical Activities of the Society of Exploration Geophysicists.

Some have raised the question, "What does geophysics have to do with something as practical as safety and accident prevention"? The obvious answer to this is "Everything." All geophysical exploration crews have, or should have, a geophysicist in charge. Practically all supervisors and responsible people in all geophysical organizations are geophysicists. Since these geophysicists hold these responsible positions where it is their responsibility to see to it that accident-free working conditions prevail and that safety and accident prevention is practiced, it follows that there is a definite connection between geophysics and safety and accident prevention.

Many industrial groups have made remarkable progress improving their safety and accident prevention records as the result of industry-wide concerted effort. Some of these industries have work conditions that are at least equal to or more dangerous than in geophysical exploration. Outstanding results have been achieved by the Portland cement industry. Their safety progress has been spearheaded by the Portland Cement Association. They have reduced their accident experience by 80 per cent. This progress is outstanding, as 142 industrial organizations, with an average of several hundred employees each, are involved. When one considers that their operations include drilling, blasting, transporting large volumes of big rocks, crushing them, firing the resulting mixture in large furnaces, and other dangerous operations, an 80 per cent reduction in accidents speaks for a job well done. One item in particular, from which we should learn a lesson, is the fact that the organizations in the cement industry who have not and are not now cooperating with this industry-wide safety program have a safety record that is from 5 to 11 times worse than that of the cooperating companies.

Another industrial group that has

†Presented before the annual meeting of the Permian Basin Geophysical Society, and Safety Committee of SEG, Midland, Texas, May, 1952.

*United Geophysical Company, Inc., Pasadena, California, Chairman, Committee on Safety, Society of Exploration Geophysicists.

achieved an outstanding record is the Pacific Coast Association of Pulp and Paper Manufacturers. This group consists of about 35 organizations in the states of Washington, Oregon, and California. They started an intensive cooperative safety effort in 1945, and since then have succeeded in lowering the number of lost-time injuries by approximately 77 per cent. It is of interest that within this group the smaller organizations have a higher rate of accidents than the larger ones. This is true in almost all industrial groups.

An industrial group that initiated a safety program in 1945, more closely allied with our own, is the American Association of Oil Well Drilling Contractors. To be sure, not all of the operators cooperated immediately in the safety effort. In the beginning, not even all the members of the Association considered the safety and accident prevention effort worth-while. Now that the value of a concerted and cooperative safety program has been proved, however, there are very few drilling operators who are not extremely safety conscious. This group's effort has resulted in a 50 to 60 per cent reduction in their insurance costs. It is estimated that this represents an annual saving in the state of Texas alone in excess of $2,500,000.

Of course, it is a mistake to emphasize only the financial or material benefits that result from an intelligent and cooperative safety effort. A much more important result, particularly to the employees, is the decrease in the amount of suffering and hardships imposed upon the workers and their families as a result of on-the-job injuries and accidents.

In relation to the just-mentioned industrial groups, let us take a look at our own — the geophysical exploration industry. At the present time there are approximately 125 geophysical operators in the United States. Among them are many small contractors with one or two survey crews, several larger contractors operating in excess of thirty geophysical crews, and many oil companies who operate their own geophysical survey parties. It is generally true that the oil companies operating their own exploration crews are very safety conscious and are presently cooperating with all the safety agencies, such as the Bureau of Mines, the National Safety Council, and the American Petroleum Institute. Among the geophysical contractors this, unfortunately, is not the case. The larger contractors, for the most part, have accident prevention programs that are carried out more or less successfully. Among the other operators, however, are many who need to be shown that worthwhile results can be obtained from a planned safety program. This is necessary so that the industry's safety efforts can be carried out on a wider basis than at present.

Only 14 companies report their accident experiences to the Exploration Group of the Petroleum Section of the National Safety Council, only 65 operators have sent their statistical accident information to the American Petroleum Institute, and about 67 companies have supplied this same information to the Bureau of Mines. To be sure, this represents a considerable improvement over that of a year ago and, as such, is an accomplishment on the part of the Safety Committee during its first year of activity.

Fig. 2 shows the accident experience of several major geophysical operators. The company whose experience is shown by the dashed and dotted lines instituted a safety program during 1946. It can be noted that this company's performance, safetywise, improved almost immediately. Another company whose accident experience is indicated by the solid lines instituted an aggressive safety program in 1949. Here, too, a marked reduction in the number and severity of the accidents resulted. This information proves that a well planned and properly supported safety and accident prevention program will produce results. The rewards, as a result of the safety effort, are in the form of reduced insurance premiums and lower operating costs to the employer, and less loss of income, decrease in hardships, and longer, healthier lives to the employees. As it is known that these benefits can be obtained, it remains, then, to make the facts available to all geophysical operators.

FIG. 3.

Basic Requirements for Successful Accident Prevention

1. Full support of management.
2. Well defined responsibilities for all parts of an organization.
3. Complete system of accident reports and analyses.
4. Adequate first aid and medical facilities.
5. Publicity to create and maintain interest in safety.
6. Proper job training with emphasis on safety.
7. Proper protective clothing.
8. Use of all possible safeguards and safety measures.
9. A program of good housekeeping enforcement.
10. Cooperate with outside agencies who can assist in safety program.

Safety *cannot* be purchased. In some instances when an operator is faced by an ultimatum from his insurance carrier to improve his safety record, the tendency is to hire a safety engineer and assume that this will solve all of the problems. The setting up of a safety program and the hiring of a safety engineer will solve absolutely nothing unless the basic concept of the responsibility of management changes within the organization involved. The responsible individuals must realize that safe operations are their responsibility and not some one elses. Only in this way will the rest of their organization, down to the helper out in the field, take the safety effort seriously. Without this, it is impossible to produce satisfactory results.

Harry H. Hillman, of the California Production Service, Inc., in a recent paper at the national meeting of the Society in Los Angeles, likened a well planned safety program and its related activities, including the safety engineer, to a handrail on a winding staircase. Management is situated at the top of this staircase, and the workers out in the field at the bottom. In order to succeed, it is necessary to descend this stairway safely from top to bottom. Along the stairway are placed the various other parts of the organization in the chain of command, from management to the fellows out in the field. It is imperative that the will to do better must be passed on down the stairway, step by step, from the management, to supervisor, to party chiefs, and finally to the workers out in the field. If a slip occurs any place along the way, the safety efforts are bound to fail. To be sure, some operators might succeed in skipping down this winding stairway without the handrail, which represents an organized and planned safety program, but the majority will find the handrail necessary, as well as extremely useful, to assure successful and safe arrival at the foot of the stairway. The importance of the determination of the responsible people of an organization to want safer operations cannot be over emphasized. It is the most important qualification necessary for a successful safety and accident prevention program. Fig. 3 shows the 10 basic requirements for an effective safety program.

The complete system of accident reports and analyses is the one that the Safety Committee is concerned with at the present time. Early this year we provided the American Petroleum Institute the names of geophysical operators. Approximately 100 of these had not previously been sent requests for information. As a result of questionnaires sent out, 50 per cent of the operators returned the questionnaire with information, but, unfortunately, only one half of these returned the information in a form which was usable to be included in the statistics to represent a yardstick indicating the safety performance of the geophysical industry. We believe this is due to the fact that many geophysical organizations do not keep adequate safety and accident statistics. As a result, they do not know whether they are making progress, safetywise, or are losing their shirts due to personnel as well as equipment accidents. It will be the Committee's task between now and the end of the year to find out from the API wherein the information was incomplete and then help those that filed the incomplete information to overcome the difficulty. It does not require much time or effort to start and maintain an efficient accident record system. A typist or clerk can take care of this matter on a part-time basis in the average organization.

On the face of it, the keeping of complete accident reports may appear to some a waste of time and effort. This, however, is an illusion, as has been shown by past experience. A complete system of accident recording and analy-

Employee Classification	Description of Accident: Handling equipment	Strains and sprains	Falls or jumps	Falls on level	Hand tools	Explosives	Particles in eyes	Burns	Traffic	Poison Oak	Misc.	Number of Injuries	Days Lost
Drillers	35	13	4	7	2	1	5	3	1	1	4	76	114
Lost time injuries	16	5	0	4	0	0	0	1	1	1	0	28	
Observers	8	5	4	1	0	0	2	0	1	0	6	27	58
Lost time injuries	2	4	1	1	0	0	0	0	0	0	4	12	
Shooters	2	3	1	1	1	2	1	0	2	0	0	13	91
Lost time injuries	0	2	1	0	0	2	0	0	1	0	0	6	
Surveyors	2	1	2	2	0	0	2	0	2	1	4	16	28
Lost time injuries	0	0	2	2	0	0	0	0	2	0	0	6	
Miscellaneous	0	0	1	1	0	0	5	0	4	1	3	15	11
Lost time injuries	0	0	0	0	0	0	0	0	3	0	0	3	
Number injuries	47	22	12	12	3	3	15	3	10	3	17	147	
Lost time injuries	18	11	4	7	0	2	0	1	7	1	4		
Days Lost	88	21	17	11	0	18	0	3	100	7	37		302

FIG. 4.

ses is an invaluable tool which tells an organization how it is doing safetywise. It is also an aid in the planning of a well coordinated safety program. It is important to know what work hazards are responsible for most accidents so that these conditions may be attacked and eliminated, thereby improving the safety performance.

Quite often, as was recently the case on one of our own parties, an analysis of several accidents revealed that one individual was involved in all of these accidents. This was not apparent at first, as he was not the injured in all cases. It was found, however, that as a driller it was his actions that injured his helpers while they were at work following his orders. A session with the party chief and this driller has straightened out the difficulty, as there have been no repetitions for several months. Without a system of accident reports and analyses this would never have been possible.

We have prepared an analysis of our accident experience. Fig. 4 shows that the largest number of injuries happen to drillers and their helpers. This group is responsible, also, for the largest number of days lost as a result of on-the-job injuries. Among the types of accidents, traffic accidents during the period examined have resulted in the largest number of days lost. The handling of mechanical equipment, mostly mounted on trucks, ranks next. In this classification, the drillers and their helpers have the largest number of accidents as well as the most days lost. From this analysis it is evident that the main problem will be to educate the drillers and their helpers to work more carefully and all of the field party personnel to drive company equipment with more caution. By improvements in equipment and work methods we must strive to reduce the accident producing work hazards in our operations.

About a year ago five geophysical companies initiated, on a voluntary, anonymous basis, a geophysical accident information exchange. The number of participants is now over twenty, representing approximately 400 crews. As a result, a lot of valuable information is exchanged. An analysis of this information by each participant provides a valuable tool that indicates the work conditions that are responsible for the majority of accidents. It is thus possible for a participant to eliminate those accidents causing work hazards from his own operations *before* accidents occur. At the national meeting of the Society, H. M. Thralls, of Seismograph Service, presented an interesting analysis of the information that had been exchanged during 1951.

On Fig. 5 are shown summaries of the information presented by Thralls. The Accident Information Exchange also indicates that the largest number of injuries occur to drillers and their helpers, with the recorders, surveyors, and shooters following in that order. One reason why the other classification is as large as it is due to the fact that in the case of many of the accidents reported it is difficult to determine the classification of the injured. Among the types of injuries, hand injuries rate first, being responsible for 21 per cent of the accidents.

Fig. 6 shows the vehicular accidents reported to the Exchange. Excessive speed is responsible for 30 per cent of

FIG. 5.

Geophysical accident information exchange — Personal injuries.

Total Injuries	497
Hand injuries	102—21%
Strains	70—14%
Eye injuries	46— 9%
Collision and upset	43— 8%
Falls	33— 7%
Moving vehicles	29— 6%
Sharp instruments	26— 5%
Falling objects	25— 5%
Poison ivy	24— 5%
Cables and power reels	18— 4%
Infections	17— 3%
Miscellaneous	63—13%
Dynamite and caps	1—.2%
Lost Time Injuries	153
Drillers	184—37%
Recorders	77—15%
Surveyors	58—12%
Shooters	51—10%
Others	127—26%

FIG. 6.

Geophysical accident information exchange — Vehicular accidents.

Number of Accidents	133
Excessive speed	39—30%
Backing	28—21%
Intersection	17—13%
Following too closely	11— 8%
Equipment failure	8— 6%
Passing	5— 4%
Improper parking	3— 2%
Miscellaneous	21—16%
Wrecked Units	42
Survey Truck	10
Water Truck	9
Shooting Truck	5
Drill Truck	3
Recording Truck	3
Miscellaneous	12

FIG. 7.

ACCIDENT EXCHANGE
January, 1952, accidents total 67

	Predicted	Observed
Lost time	21	20
Fatalities	0	1
Drill	25	31
Recording	10	12
Survey	8	8
Shooting	7	4
Others	17	12

	Predicted	Observed
Hand injuries	14	11
Strains	9	8
Eye injuries	6	8
Collision and upset	6	3
Falls	5	5
Moving vehicles	4	2
Sharp instruments	3	3
Falling objects	3	6
Poison ivy	3	3
Cables and power reels	3	3
Infection	2	2
Miscellaneous	9	13
Dynamite and caps	0	0

FIG. 8.

ACCIDENT EXCHANGE
January, 1952, collision or upsets total —23 collisions—6 wrecked units

	Predicted	Observed
Excessive speed	7	5
Backing	5	3
Intersection	3	2
Improper interval	2	2
Equipment failures	1	1
Passing	1	1
Improper parking	0	0
Miscellaneous	4	9
Dynamite and caps	0	0

Wrecked Units

	Predicted	Observed
Survey	1.4	1
Water	1.3	2
Shooting	.8	0
Drill	.4	2
Records	.4	0
Others	1.7	1

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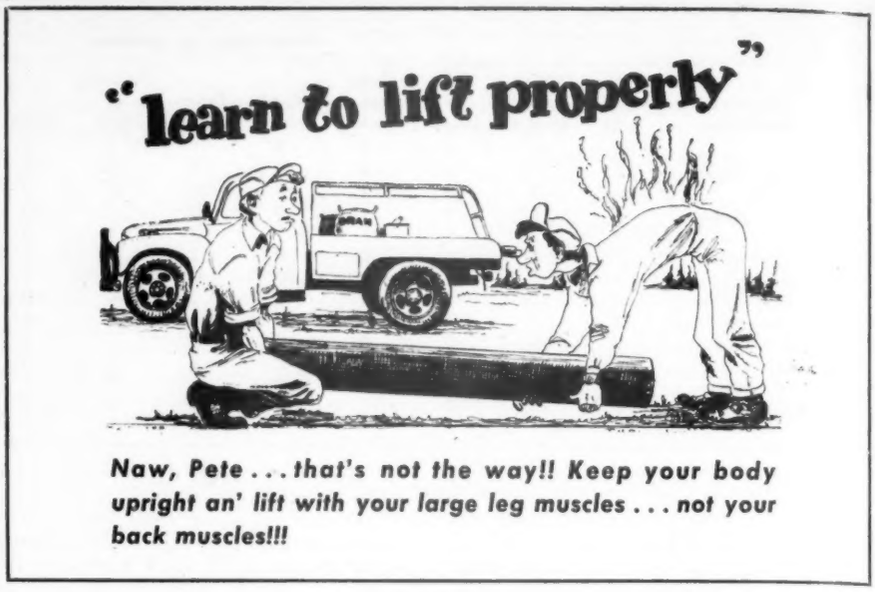

Naw, Pete . . . that's not the way!! Keep your body upright an' lift with your large leg muscles . . . not your back muscles!!!

FIG. 9

Well fer gawsh sakes, fella!!! I showed ya an showed ya how to hold that breakout wrench.

FIG. 10.

Protect your eyes from the mud that is squirted from the drain hole in the sand line plug!!!

FIG. 11.

the total vehicular accidents, and backing accidents, where vehicles collided with objects while being backed up without proper caution, were next, with 21 per cent. Among the wrecked units, survey trucks represent 25 per cent of the total number wrecked.

From the monthly averages of the information submitted, Thralls predicted ahead of time what the accident experience of the participating organizations would be for the month of January. The results of this prediction pertaining to personal injury accidents are shown in Fig. 7. Considering the close correlation between the predicted and observed, it is remarkable how uniform human behavior becomes, even as it pertains to accidents when a broad enough base for an average is established.

The results, vehicularwise, are shown in Fig. 8. The correlation between predicted and observed statistics during the month of January is surprising. It is this predictability that enhances the value of the Geophysical Accident Information Exchange to the participants, as it enables them to eliminate work hazards *before* accidents happen.

Since April, 1952, the Safety Committee of the Society of Exploration Geophysicists has received permission from the majority of the participants in the Geophysical Accident Information Exchange to analyze this information at regular intervals and make it available to the industry. It is planned to call attention to these work conditions, which are responsible for the largest number

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If you are operating in a corrosive field, you need accurate, reliable information on the degree of *internal* corrosion damage in the tubing and casing of your oil or gas wells. Otis wire line crews, running the Otis Tubing Caliper under pressure, can obtain this data for you quickly and economically *without killing the well or pulling the string for surface inspection.* Spring-loaded feelers on the Otis Caliper, pressing against the inner wall of the tubing, actuate a stylus inside of the instrument that plots the location of corrosion pits on a special metal chart. After the survey is completed, the charts are photostated, tabulated, and analyzed, and included as part of a comprehensive report on the exact condition of the well as surveyed. The extent of corrosion damage to the entire string — including the tubing hanger — or to any individual joint can be determined at a glance. If necessary, the metal chart can be tabulated and interpreted at the well site if an immediate report is desired. In view of the tubular goods situation, don't risk the consequences of internal corrosion damage to your tubing and casing. Make use of the vast experience Otis engineers have gained from surveying thousands of producing wells. Contact your nearest Otis office for sample well reports and descriptive literature on the Otis caliper service, or write to us at P. O. Box 7206 in Dallas. There's no obligation.

Otis reports include photostats of actual Caliper charts plotted during run

Calipering pumping wells for rod wear

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OTIS PRESSURE CONTROL, INC.

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of accidents by means of safety posters and bulletins. By doing this, we feel that it will help improve the safety record and stimulate an interest in safety and accident prevention of those organizations that are not now much concerned about this problem.

Also among the basic requirements for an efficient accident prevention program is the publicity to create and maintain an interest in safety. The Safety Committee of the SEG has gathered safety posters, mostly drawn by workers in the industry. Some posters are shown in Figs. 9, 10, 11, and 12.* These safety posters are being distributed on a nonprofit basis through the Tulsa business office of the SEG. The Committee is endeavoring to add to the collection of posters that have been distributed. Approximately 10,000 of these posters have been sold to various geophysical operators. We are planning to make available additional posters, and an appeal for contribution of additional posters has recently been made.

FIG. 12.

Other industrial groups have shown what can be done by cooperative safety effort. Their experience has indicated that an enormous amount of money can be saved, which in these days of ever-increasing operating costs should certainly be welcomed by most organizations. The direct savings resulting from a well coordinated and supported accident prevention program are not only due to reduced insurance premiums, but also due to more efficient operations and lower equipment upkeep expense as a result of more careful handling by the personnel. Lower indirect accident costs, which are usually three to four times the amount of the direct expense, will also result. The Safety Committee of the Society of Exploration Geophysicists will continue its endeavor to interest the industry in helping itself because we, as individuals, have found that it pays to be concerned about safety and that there is no substitute for intelligent accident prevention planning. ★ ★ ★

*These 4 figures are distributed by Society of Exploration Geophysicists, Committee on Safety.

—another reason for TOTCO on your rig

TOTCO men make the rough calls in stride... hundreds of trips into swamps, in the desert, and over boggy roads at night and in storms. Our service organization will go on making all the trips you need anytime, anywhere.

But the *values in service* to you are (1) trained men able and *willing* to help you, and (2) our responsibility to build the finest Recorder... one that will give the ultimate in trouble-free operation.

The TOTCO service organization has been building for twenty years... a long-time association with drilling requirements. You'll find TOTCO organized to gain your appreciation... because our service is based on what we've learned you want.

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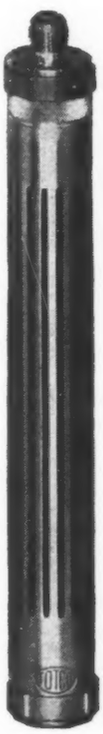


TOTCO Recorder

YOU CAN TAKE TOTCO READINGS ANYTIME

Run in and out on measuring line.

Dropped down drill pipe; picked up with core barrel overshot.

Dropped down drill pipe; recovered when bit is changed.

Run in the Recorder connected to a core barrel overshot when picking up a retractable core barrel.

Run in and out on ordinary sand line.

Be **SURE** *you know, use* **TOTCO**

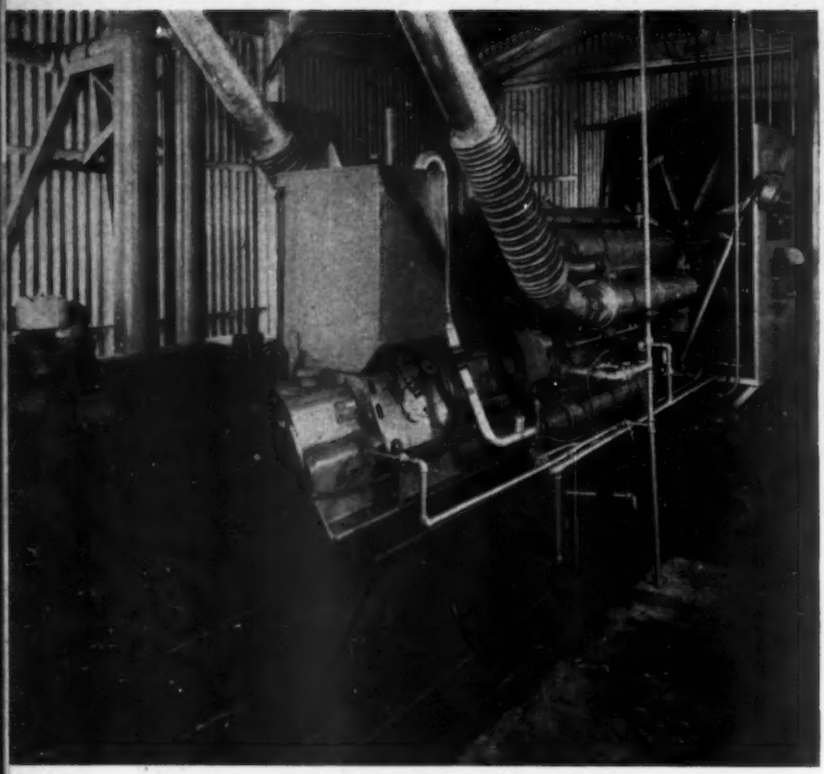


FIG. 1. This specially developed pump and power unit forms the heart of the Reed hydraulic laboratory. Pump is powered by a 925 hp engine and is capable of producing pressures of over 8000 psi. Nozzles have been studied where fluid velocities are in excess of 400 ft per second. Typical testing requirements often call for 400 gal per minute at 2000 psi.

FIG. 2. Main control panel for drilling fluid pump. Intercoms are used so operators can keep in contact with remote testing station and other control stations.

Hydraulic Research Holds Key to Improved Rock Bit Performance

E. G. BOICE*

CONSIDERABLE future improvement of rock bits as we know them today is to be expected in the improvement of their hydraulic action. That does not mean that no improvement can be expected in tooth geometry, metallurgy, and bearing design, but simply that these factors pertaining to rock bits have received more attention in the past and are presently at a much higher state of development than the hydraulic action of the mud stream at the bottom of the hole. In other words, an era of hydraulics in rock bit design is being unfolded.

Before going any further, it is well to define exactly what can, and what can not, be expected from hydraulics in rock bits.

Effect of Fluid Nozzle

There is an impression that rocks bits using high velocity nozzles get part of their drilling effect from the fluid jet itself. Studies do not confirm this assumption. Tests made to date confirm the fact that the fluid from the nozzle itself does little or no drilling. Why, then, is hydraulics so important to bit design? The answer is simply this: One of the greatest problems associated with drilling—and it has been a problem since the first wells were drilled—is the efficient removal of cuttings from the bottom of the hole. Wells can only be drilled as fast as the loosened formation is removed from the hole; so we look to the mud stream to blast the cuttings away from the bottom of the hole and up into the return mud stream before they are recut by the bit. If they remain on the bottom of the hole and are recut, they no doubt cause—

New Light on Rock Bit Efficiency

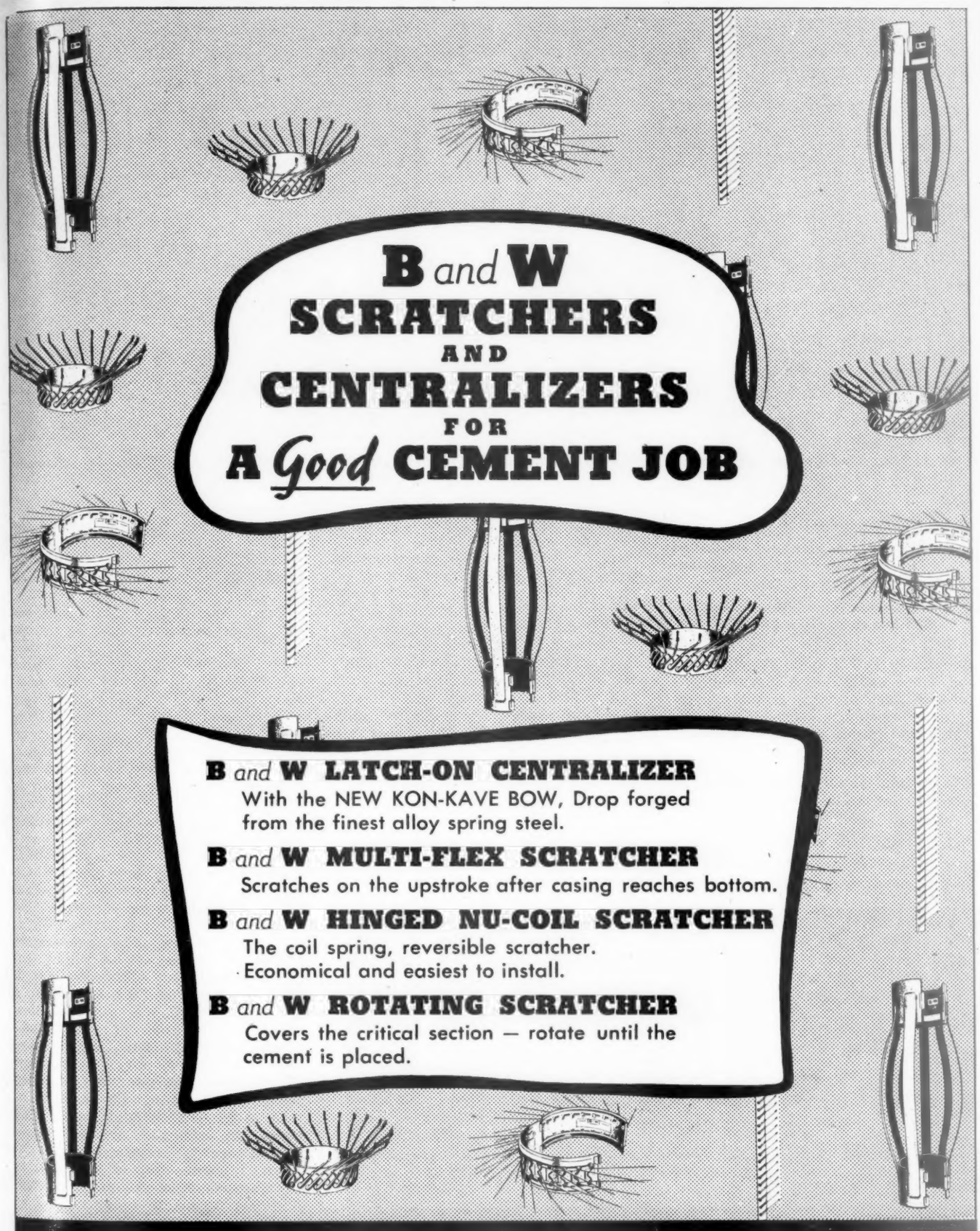
The latest comprehensive insight of rock bit design research is presented.

Research has thus far proved erroneous the idea that rock bits using high velocity nozzles get part of their drilling effect from the fluid jet itself.

The importance of hydraulic considerations, and how higher efficiency drilling operations can be obtained are explained.

The present research trend may lead to the doubling of rock bit efficiency in the near future.

*Director of Research for Reed Roller Bit Company.



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B and W LATCH-ON CENTRALIZER
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FIG. 3. Bits or test nozzles are connected to the horizontal flow line to make photographic studies of nozzle discharge conditions.

1. **Slower penetration.**
2. **Balling up due to continued kneading after the formation cuttings become wet.**
3. **Excess wear on cutter teeth resulting in shorter bit life.**

The ideal hydraulic action of a bit would keep the hole bottom so clean that the cutters would always be cutting new formation and never be grinding or recutting formation previously fractured. This ideal has not yet been reached in actual practice, but research is pointing the way toward tremendous improvements. It would not be surprising to see as much as a 50 per cent increase in rock bit efficiency brought about solely by the improvements in the fluid action on the bottom of the hole. Certainly, improvements in other elements of the fluid system such as slush pumps, swivels, kelly, drill pipe, drill collars, etc., will be made. We are able to do things today with rock bit design that we could not do a few years ago. As further improvements are made in various elements of the fluid system, there will become available more bottom hole horsepower that the rock bit designer can well utilize for better rock bit performance.

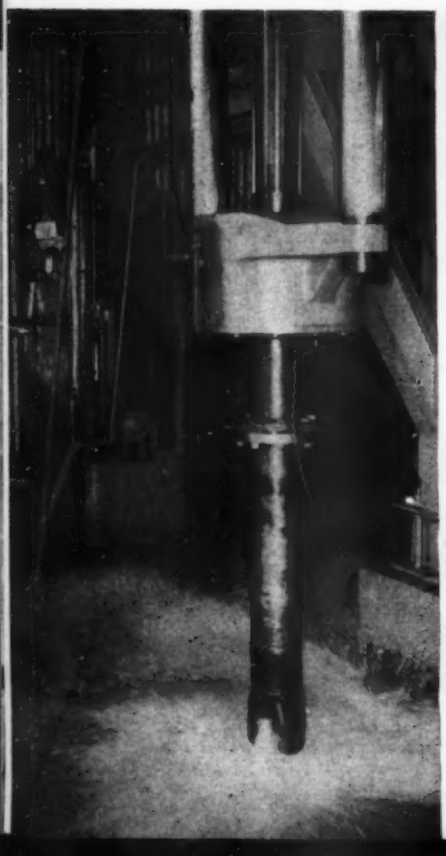
One of the most important functions of a hydraulic laboratory is to give accelerated service tests of the mechanical connection between the nozzle and the rest of the bit. Most of the nozzle materials best suited to resist the severe abrasion and erosion of high velocity fluid are exceptionally difficult to connect to the bit bodies. Ceramic nozzles, and nozzles of sintered tungsten carbide, which are the most resistant to abrasion, have so far defied all attempts to be successfully and consistently welded or otherwise cemented to the remainder of the bit. Various mechanical means of retaining these nozzles have been developed and tested at the hydraulic laboratory to ensure successful field performance.

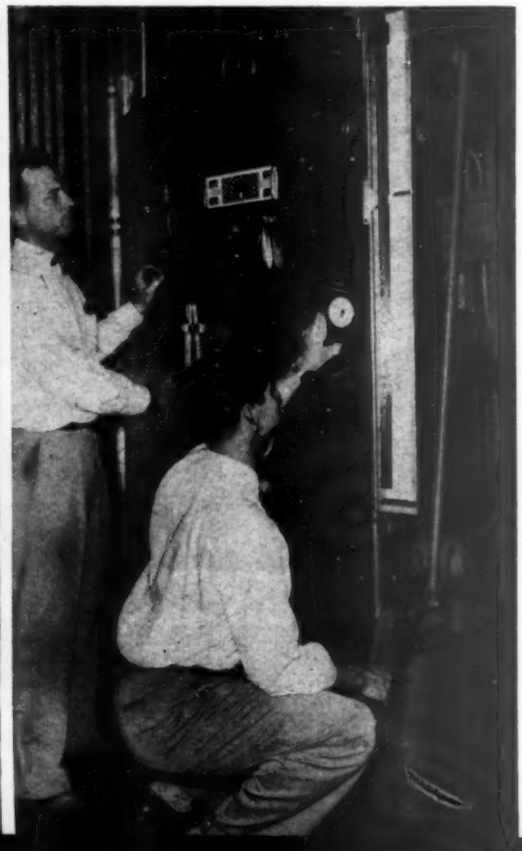
A nozzle design under investigation can be run in one of the drilling machines to simulate actual field vibration conditions, or it can be connected to a horizontal flow line in order to allow accelerated abrasion tests or photographic study of the flow characteristics. Typical laboratory pressure and flow meter devices are used to determine pressure losses through the nozzle.

By using abrasive fluids, accelerated wear tests of nozzles are made—preventing premature nozzle cutouts at unexpected places. Nozzles subjected to this abrasion test have provided valuable data for nozzle designers, just as wind tunnel tests provide valuable data for aircraft designers. Astounding discoveries unfold as the laboratory engineers observe the conditions imposed when changing from laminar to turbulent flow.

FIG. 4. Left, typical drilling fluid conditions for drilling test operation. Control panel for drilling weight and rpm of bit in the background.

FIG. 5. Right, from this drilling control station the engineers control drilling weight, rpm of the bit and record performance data. They are also able to control fluid flow by means of direct intercom to the drilling fluid pump control station.

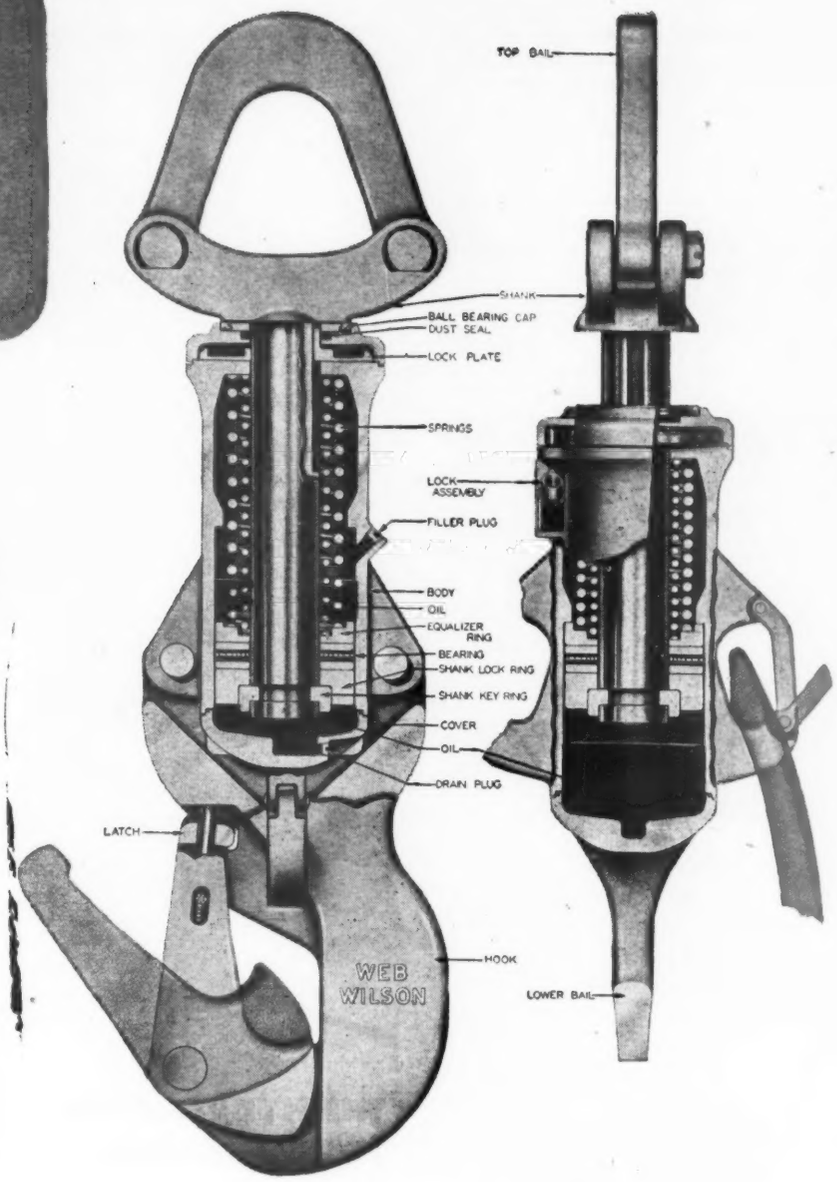




Horsepower Considerations

Since the introduction of high mud pressures and volumes in drilling, many operators are seeking methods of in-

That oil cushion saves a lot of tool joint threads



Web Wilson Connectors and Connector Hooks

... contain an "oil-bath" in which the plunger and bearing operate. This oil cushion not only insures perfect lubrication of the bearing, but also provides controlled hydraulic action of the spring,—an exclusive feature which eliminates bouncing the pin-end thread on the box end of tool joints when breaking out, and avoids battering the threads and sealing shoulders of tool joints. ★ The oil cushion feature minimizes shock on hoisting equipment and the entire drilling string, and makes the tool ideal for jarring or fishing.

OTHER IMPORTANT ADVANTAGES: Bearings and Spring work in an almost constant oil bath. ★ The new Ball Bearing Cap assures positive, free swivel action. ★ Load-Carrying Ears are now on the Hook Member of the Connector-Hook (instead of the Body) thus increasing head room between the bottom of the hook and the elevator. ★ No "Load-carrying" threads—Anti-Friction Roller Bearings—8-Point Locking Mechanism. ★ Top Bail fits all standard traveling blocks; and the shank (with upper bail removed) connects directly to traveling blocks.

WEB WILSON Oil Tools INC *FIELD PROVEN*

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creasing the hydraulic efficiency of their rigs. The horsepower required to force fluid through a tube or pipe is inversely proportional to slightly more than the fourth power of the diameter. Thus, as the diameter decreases, the horsepower required rises very rapidly. This fact immediately focuses attention to the drill collars whose bores are much smaller than those of the pipe or tool joints with which they operate.

The present day practice of using long strings of drill collars has increased the horsepower loss through the drill collars to such an extent that in many cases it is a limiting factor in the depth that can be drilled with adequate return velocities. One of the prime reasons for the use of many collars is to have a concentration of weight available at the bit. Increasing the collar bore to save horsepower results in a comparatively minor loss of weight.

For example, suppose there are 25 collars in the string. The collars are 6½ in. OD by 2¼ in. ID and 400 gal per minute of 10-lb mud is circulated.

ID	PD psi	HP loss in h p	HP decrease, per cent	Weight of collar, pounds	Loss weight, per cent
2¼	638	175		74,000	
2⅜	480	130	26	73,500	⅓
2½	375	102	42	72,200	2½
2⅝	300	82	53	70,800	4
2¾	255	69	60.5	69,600	6
2⅞	195	53	70	68,000	8½

From the above chart, it is noted when the bore of the collar is increased to 2⅜ in., which is only ⅛-in., that the pressure drop through the drill collars is 158 lb less; that 45 hp is saved, and that the loss in weight is one ½ of 1 per cent. Similar comparisons can be made with the various bores shown. (See Table 1 for actual difference in horsepower requirements.)

TABLE 1.

In an 8¾ hole using 4½-in. drill pipe, 400 gpm are required to produce an annular return velocity of 175 ft per minute, which many people think is a safe return. Therefore, for the following example assume 400 gpm is circulated and carries 10 lb mud. Assume that 15 drill collars are used.

Bore	Pressure required to pump fluid thru Bore	Horsepower required to pump fluid thru Bore
2¼.....	383 psi	103
2⅞.....	117 psi	32
Difference...	266 psi	71
or if 20 drill collars were used it would look like this		
2¼.....	510 psi	140
2⅞.....	156 psi	42
Difference...	354 psi	98

Note: That by increasing the bore of the drill collar, or in other words by sacrificing a small amount of wieght, a considerable reduction in pump horsepower requirement is achieved. To have obtained this reduction is considerably more advantageous than to have had the extra weight.

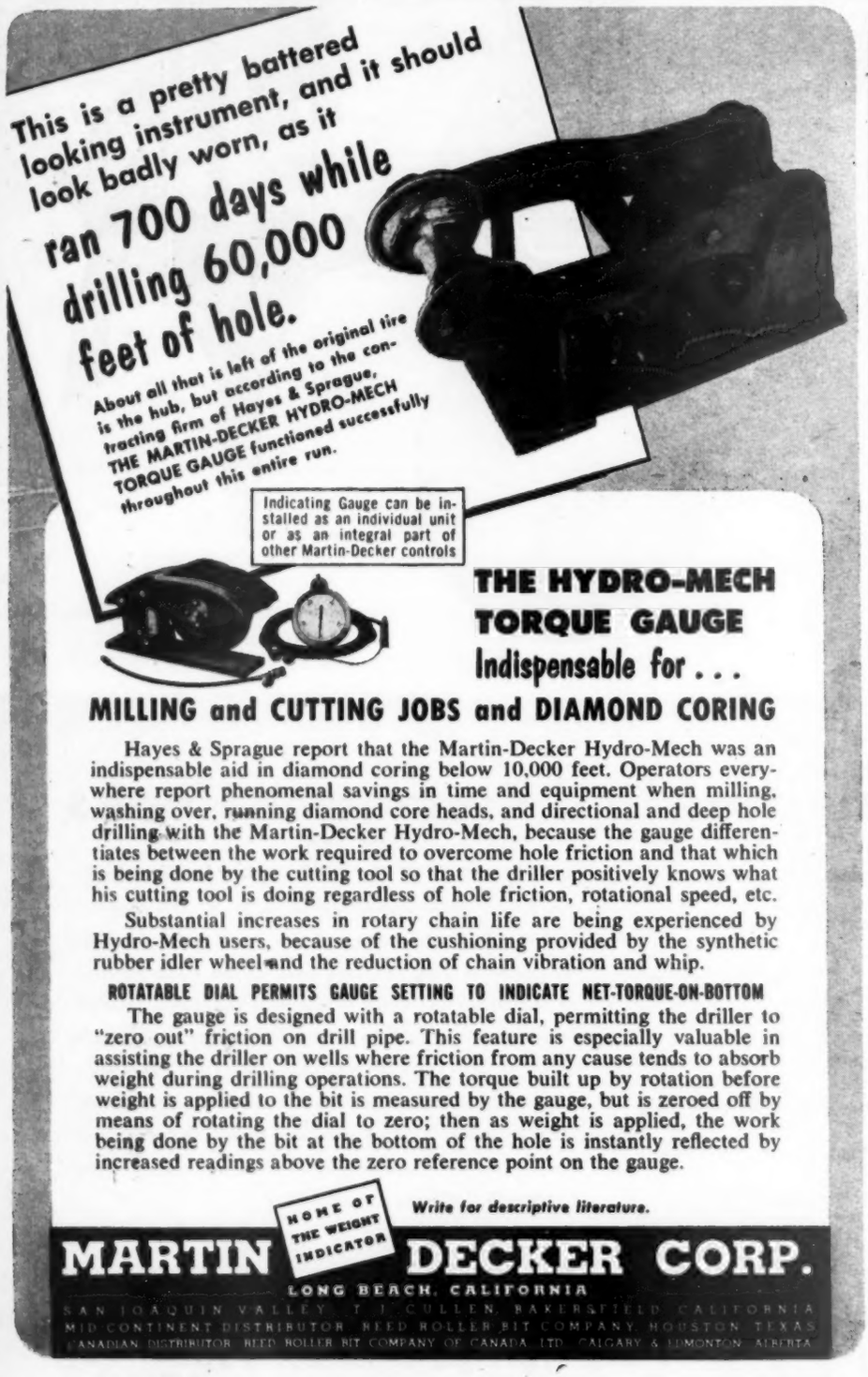
This saving in horsepower not only permits more efficient drilling, but increases the depth to which the well can be drilled and still maintain adequate mud flow.

If 4½-in. full hole joints are used with the above string, the rule is, roughly, that 100 lb of pressure drop through the collars would be equivalent to that through 1000 ft of drill pipe. Therefore, in changing the drill collar bore from 2¼ in. to 2⅞ in. the operator should be able to drill approximately 4000 ft deeper with the same pumps.

All this research has already permitted the development of bits with startingly improved hydraulic characteristics and it may be expected that further substantial improvements will follow in the near future. An era of hydraulics in rock bit design has commenced and before it is finished, it is highly probable that rock bit drilling efficiency may be more than doubled. * * *

Gasoline Power Increased

Two gallons of today's anti-knock gasoline are equal to three gallons of gasoline made 25 years ago, recent tests have proved. A 1921 model car using fuel of 1925 vintage made 14.95 miles per gallon in the experiment, and a modern car with an 8-to-1 compression ratio using a 1950 fuel, made 25.7 miles per gallon.


This is a pretty battered looking instrument, and it should look badly worn, as it
ran 700 days while drilling 60,000 feet of hole.
About all that is left of the original tire is the hub, but according to the contracting firm of Hayes & Sprague, THE MARTIN-DECKER HYDRO-MECH TORQUE GAUGE functioned successfully throughout this entire run.
Indicating Gauge can be installed as an individual unit or as an integral part of other Martin-Decker controls
THE HYDRO-MECH TORQUE GAUGE
Indispensable for . . .
MILLING and CUTTING JOBS and DIAMOND CORING
Hayes & Sprague report that the Martin-Decker Hydro-Mech was an indispensable aid in diamond coring below 10,000 feet. Operators everywhere report phenomenal savings in time and equipment when milling, washing over, running diamond core heads, and directional and deep hole drilling with the Martin-Decker Hydro-Mech, because the gauge differentiates between the work required to overcome hole friction and that which is being done by the cutting tool so that the driller positively knows what his cutting tool is doing regardless of hole friction, rotational speed, etc.
Substantial increases in rotary chain life are being experienced by Hydro-Mech users, because of the cushioning provided by the synthetic rubber idler wheel and the reduction of chain vibration and whip.
ROTATABLE DIAL PERMITS GAUGE SETTING TO INDICATE NET-TORQUE-ON-BOTTOM
The gauge is designed with a rotatable dial, permitting the driller to "zero out" friction on drill pipe. This feature is especially valuable in assisting the driller on wells where friction from any cause tends to absorb weight during drilling operations. The torque built up by rotation before weight is applied to the bit is measured by the gauge, but is zeroed off by means of rotating the dial to zero; then as weight is applied, the work being done by the bit at the bottom of the hole is instantly reflected by increased readings above the zero reference point on the gauge.
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Write for descriptive literature.
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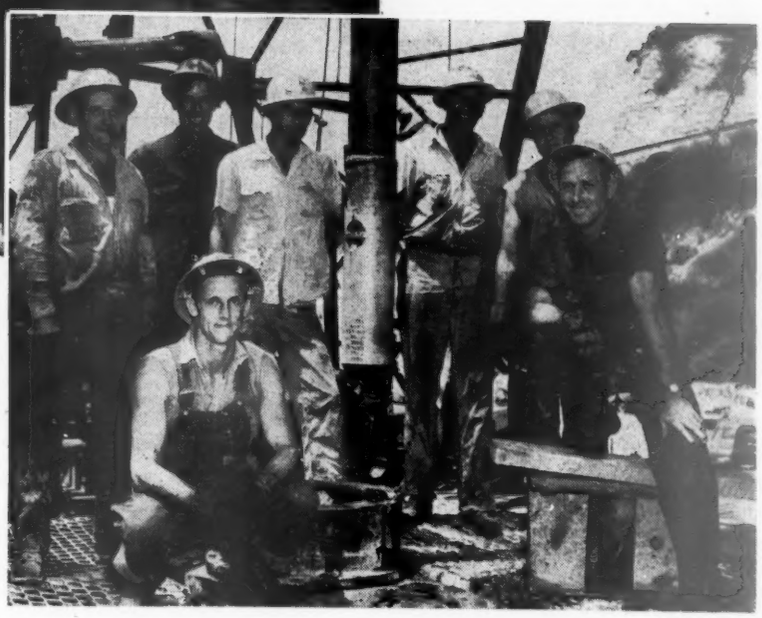
Watching the casing run begin are: Dick Weaver, Lloyd Corporation; M. B. Conrad and R. R. Robison, Baker Oil Tools; Tom Hammer, Drillex; B. P. Bayliss, Lloyd.



Crew on well were: Standing, M. W. Essex, Ralph Bruce, and Lou Kimes, rotary helpers, D. A. Hungerford, driller, J. D. Messmore, rotary helper, R. W. Ash, driller, and kneeling, I. B. Beeson, cathead man.

Is This a Record Casing Run?

Three tools aid in saving time on operation; all of them are new; one is not yet even in production

RICHARD SNEDDON*

UP on the Lloyd Corporation Well No. 42 in the Ventura Avenue field on Wednesday, August 6, 1952, a well integrated little band of experts, with some thoroughly modern tools, gave a preview of a coming casing technique that ought to make operators everywhere sit up and take notice. Without a hitch, they ran 11,180 ft of 7-in. casing (7000 ft of 26 lb, and 4180 ft of 29 lb) in a total elapsed time of 6 hr and 30 min. That was from the time the shoe joint was picked up until the cementing head was in place. Take off 35 min for running-in the first 5 joints of pipe, welding the box end joint of the differential fill-up collar and installing and welding the centralizers, and you are left with 5 hr and 55 min for the running of 263 joints of casing—an average of approximately 45 joints an hour. If that isn't a record, it will do until one comes along.

The credit for this outstanding achievement belongs to three tools, one of which is so new that it is not yet in production. They are a set of air-operated casing tongs, first of their kind, designed and built in Los Angeles[1] especially for D. F. "Duke" Bloom of Bakersfield, California, who, with his assistant, Hal Jones, operated the tongs throughout the record run; a differential fill-up, casing shoe and collar, also designed and built in Los Angeles[2] and now in the final field testing stage; and third, an ingenious little instantaneously attachable and detachable collar for guarding casing threads against damage during the operation.[3]

Before going into a dissertation on the respective contributions of these three items, perhaps it would be advisable at this stage to dispose of the well history: Lloyd No. 42, located on Section 19-T 3M-R 22W, was drilled under contract to Lloyd Corporation by Drilling and Exploration Company. It was spudded on June 24, 1952, and a surface string of 13⅜-in., 54.5-lb casing was set at 970 ft. After this had been cemented, an 11-in. hole had been continued to 11,180

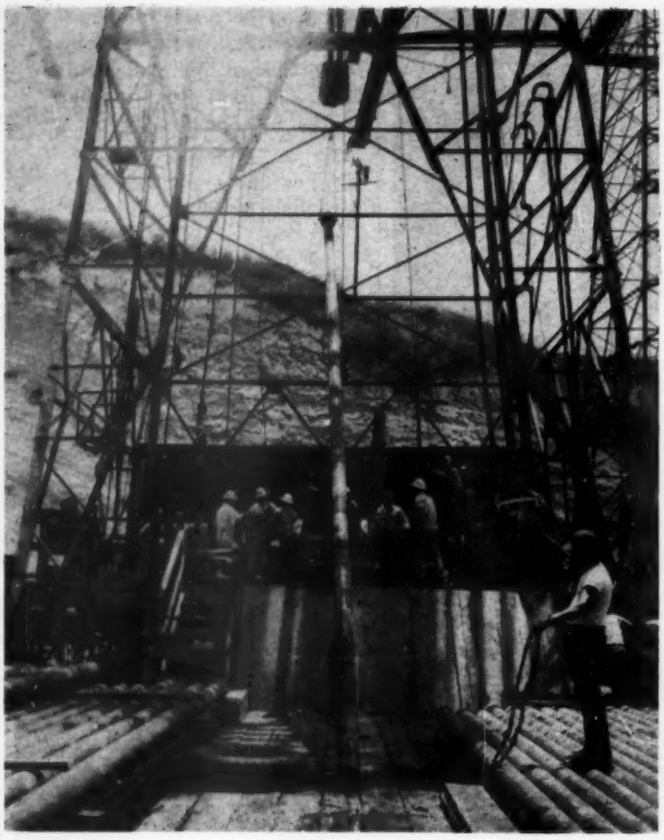
*Pacific Coast Editor.

[1]By Hillman-Kelley.

[2]By Baker Oil Tools, Inc.

[3]Furnished by Robinson Oil Tool Service.

EXCLUSIVE



Preparing to run first joint of casing with differential fill-up shoe attached, on Lloyd well in Ventura Avenue field.

D. F. "Duke" Bloom and Hal Jones of D. F. "Duke" Bloom Company, Bakersfield, with their air operated casing tongs.

ft. It was reamed and smoothed before running the 7-in. casing and showed no evidence of caving or other disturbing circumstance. The hole was straight and in good shape when the record run was begun, and was standing full of 80-lb 50-centipoise viscosity mud.

The air tongs were, as already intimated, especially built for the Bloom organization and the outfit consists essentially of a multi-vane air motor[4], equipped to take casing sizes from 5½-in. through 8⅝-in. When in full operation it has a high speed of 70 rpm which is retained throughout the complete spinning action of the pipe. It is then dropped to a lower gear and applies approximately 3500 lb/ft of torque for the final tightening up process. The tongs are actually capable of exerting a total torque of about 9000 lb/ft. Two compressors, one a standby, provide the necessary air at a pressure of 150 psi. These are high speed units, each able to compress 60 cu ft of air per minute. Power for the compressors is derived from a stationary internal combustion engine[5].

The virtues of the air tongs are quite marked. They can, to begin with, be operated at a high rate of speed. It actually takes 18 to 22 sec to complete the make up of each joint and Duke Bloom claims to have run as many as 58 40-ft joints in an hour. That, however, was when using side-door elevators instead of the doughnut type that was used on this job. It should be noted also that after the joint has been made up, there is no heating of the coupling as is so common when a spinning rope is employed and a pinching action results because of the relative positions of the rope and the cathead. By the same token, the elimination of the spinning rope removes a hazard that has been the cause of many a serious accident. It is, however, when used in combination with the other items mentioned, that the advantages of the air tongs become most apparent.

The differential fill-up shoe, for example, is specifically designed to permit casing to be run in the hole at much faster than normal speed, and so to avoid as far as possible the likelihood of freezing because of formation sloughing, cave-ins, or other undesirable occurences. (Every driller knows that the more nearly he is able to keep the casing in constant controlled motion while being lowered into the hole, the less likely it is to become stuck.) The fill-up shoe is so constructed that it automatically allows the casing to fill from the bottom of the string, thus eliminating the chance of air entrapment with subsequent spill-overs that take time and effort to clean up and in the meantime impose unnecessary hardships and hazards.

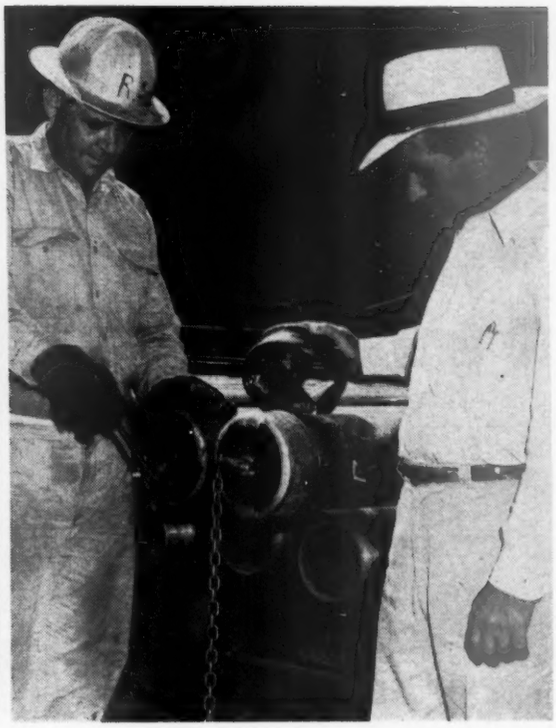
A single unit of fill-up equipment (either the shoe or the collar) is also designed as to automatically admit well fluid into the casing as it is being run until the fluid level inside of the casing equals 90 per cent of the fluid level in the hole. If at any time it appears that the weight of the string is approaching the safety limit of the rig, the fill-up equipment can be converted to conventional floating equipment simply by pressuring the casing enough to free the ball of the back-pressure valve. After this is done, the fill-up shoe or collar provides the back-pressure valve for cementing and, of course, can be drilled out when that becomes necessary. When two pieces of differential fill-up equipment (both the shoe and the collar) are run in the casing string, as was the case in the Lloyd No. 42 run, well fluid is permitted to rise in the casing to within 81 per cent of the fluid level of the well. In this instance *double* assurance is given that after the cement job has been completed, there will be no equalizing of fluid between the inside of the casing and the casing-well bore annulus.

This automatic partial filling speeds up the entire operation because it obviates the need for stoppages to fill up the casing by other means in order to prevent collapse at the extraordinarily high pressures that exist at the bottom of the mud column—particularly in a deep hole. In addition, fill-up equipment reduces the "ram effect" that otherwise might act to break down a weak formation and cause lost circulation. It further creates the minimum of disturbance and consequently is very unlikely to displace mud cake or any part of it from the walls of the hole.

The third item that contributed to the remarkably quick casing job at Lloyd No. 42 was the clever thread protector already referred to. This device was

[4]Ingersol-Rand.
[5]International U-2-A.

M. B. Conrad with Baker differential fill-up shoe.



R. S. Cronian and T. K. Robinson demonstrate the Quick-E-Protector, designed to prevent damaged threads.

patented by M. C. Baker of Long Beach. It has been in use for several years in California, but so far has not found its way to the Mid-Continent, or, indeed, to any other out of state area. It is simply a collar that fits over the threaded end of the casing. It operates hydraulically and is held in place by pins that attach it to the inside of the pipe. The whole thing is not unlike an automobile brake. The trigger on a cam operates a master plunger which in turn actuates the pins that hold the protector on the pipe with about 2700 psi. The pins are not sharp, but somewhat resemble so many center punches that grip the inside of the casing and so hold the protector in place.

These thread protectors consume no running time whatever. They are placed on the joint before it is picked up, and they are yanked off instantly by a light rope attached to the release mechanism as soon as the end of the joint is safely over the ramp. They reduce practically to nil the possibility of injured threads with subsequent cross-threading that delays make-up, and in many instances eventually necessitates re-threading. The latter contingency, besides involving a protracted delay, piles up transportation costs and is definitely to be avoided.

Again it is to be emphasized that the fast time made on the casing run at Lloyd No. 42 was attributable to all three of the items described here. It would have been impossible to take advantage of the fast acting air tongs if there hadn't been differential fill-up equipment to automatically control mud entry into the casing, to prevent actual collapse, and to obviate the slow working out of entrapped air that is required under normal circumstances. There might certainly have been no record if the protectors hadn't been effective in preventing damage to the casing threads, thus permitting the operation to go on smoothly and without interruption.

Finally, there would not have been such a fine performance to report had it not been for the cooperative effort of the men who supervised the job and the men who actually ran it. In charge for Lloyd Corporation were Dick Weaver, drilling superintendent, Ben Bayliss, petroleum engineer, and H. Kane, geologist, who helped tie all the separate activities into a coordinate whole. Tom Hammer, Drilling and Exploration Company toolpusher, fitted his crews admirably to the new technique. Operating the tongs were D. F. "Duke" Bloom and Hal Jones. The former wasn't altogether pleased with the performance. He is still sure that with a little more experience on the part of the derrick crews, he can do an overall job at the average time of 50 joints an hour. The new record thus represents an increase of 15 joints an hour, or a time saving of 50 per cent that is completely attributable to the three items described, and is certainly no inconsiderable gain.

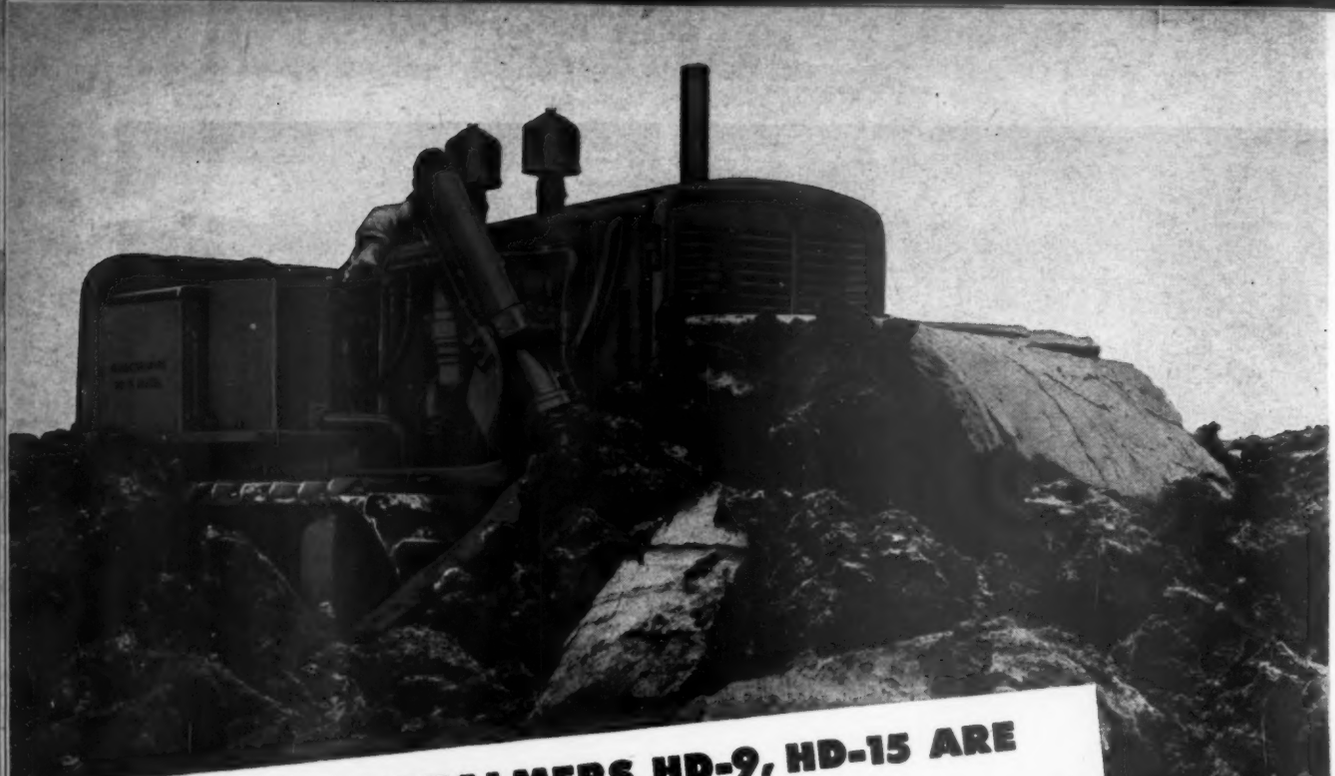
It was remarked in the beginning that the differential fill-up equipment is still in the field testing stage. Present to check up on its performance and well pleased with the overall functioning of the device were Martin Conrad, Baker Oil Tool engineer, and R. R. "Robie" Robison, field service engineer for the same institution in Ventura.

The protectors were operated under the immediate direction of T. E. Robinson and R. S. Cronian of Robinson Oil Tools Company. This interesting and effective little device is not altogether new, but its use, so far, has been confined to California and, in any case, it, too, performed its function in this instance in a very adequate way.

The drilling crews that handled the job were made up of drillers, R. W. Ash and D. A. Hungerford; cathead man, I. B. Beeson; rotary helpers, M. W. Essex, R. Bruce, L. A. Kimes, and J. D. Messmore. It was their first handling of an assignment of this kind, but they rose to the occasion nobly as the results plainly indicate. A distinct note of skepticism as to the value of the proposed departure in casing technique could be detected in the dog house before the run started, but when it was all over, everything was rosy again and the new routine had obviously earned unqualified approval.

The entire adventure is just one more vindication of the fact that there is nothing that can't be improved. It is very easy to assume that this method or that device is the acme of perfection, but if we examine any operation or any piece of equipment long enough and critically enough, we shall almost certainly find some modification, some manner in which it can be made more effective and eventually more economical. The casing run record on Lloyd No. 42 is the logical result of that type of dissatisfaction which not only excites the creation of new tools and techniques, but is even responsible for the creation of new industries.

The casing tongs and the differential fill-up unit are brand new developments of a highly inventive age. The thread protector is of comparatively recent origin, but its effectiveness has already been well established. These three implements, together with the coordinated and correlated efforts of oil company engineers and technologists, have ushered in a new operational era in the drilling field that will eventually produce even more exciting results. * * *



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Rotary Drilling Lines

How to evaluate moving and cutting off programs . . . acceptance or rejection . . . analysis of bends

R. H. STEINBRUCK

It may well be said that today is the era of the ton mile. Many articles are being written, ideas are being formulated, and moving and cutting-off programs are beginning to jell.

Until quite recently a comparatively few number of people have delved into the mysteries of ton miles. The general drilling practice involved using just enough line to string up the rotary rig. If ton mile records were kept at all, they merely served the purpose of checking performance of each line against the average.

Today a new concept of ton mile records is being evolved, that of measuring the effectiveness of a moving and cutting-off program. The fact that for some particular operation wire rope service has been increased from 5 to 8 ton miles per foot is taken to mean that the operation is now more efficient.

Such an approach must be made with caution. What actually is wanted is not just increased ton mile service, but lower operating costs. Before any kind of a program is adopted or continued, the first step is to determine whether or not the desired results can or are being obtained.

If the unit of cost measure is so many ton miles per dollar, the dollar value must reflect the cost of the line plus the cost of the program. The effect of increased supervision and clerical work enters into the cost as well as freight, handling, string-up time, rig down time, etc.

For maximum economic benefits, it is essential that the program cost be kept to a minimum. Supervision and clerical work can be limited if field crews are provided with a simplified ton mile chart and an easy to follow moving and cutting-off program. Reel weights can be limited to those that are readily hauled and handled, and string-up time and rig down time can be lessened if the traveling block is hung from the rigging when string-ups, moves, or cuts are made.

Some drillers who operate portable rigs and keep no ton mile records, figure that maximum economy results from their using just enough line for the string-up. In one case the reel of line is mounted on the rig and moves along with it so that string-up time and handling are reduced to a minimum when setting up at a new location. In another case, when the line is discarded it is sent back to the yard where it is rewound, inspected and turned end for end. The rewound reel is marked as "good for 5-6000-ft wells" etc., according to condition.

The Author

R. H. Steinbruck received a mechanical engineering degree from the University of California at Berkeley. After graduation he had experience in surveying and construction until 1937 when he went to work for the E. H. Edwards Company.

Experience at Edwards included machine design and operation, field engineering and wire rope design along with 10 years as rope department superintendent. Currently he is a registered professional engineer and chief wire rope engineer for the Edwards organization.

It becomes apparent from such examples as are cited above that ton mile records and moving and cutting off programs cannot universally be considered as the answer to lower operating cost. In some cases greater savings are made just from changes in operating methods. In other cases substantial savings can be made by a combination of a moving and cutting-off program and changes in operating methods. It all depends upon individual needs.

If after a thorough analysis the fact is established that the lowest operating costs can be attained only through the adoption or continuation of a practice that includes a moving and cutting-off program, then the next step is to decide which program will suit the operation best.

Unfortunately there is no one practice that will cover the many combinations of rig designs, drilling depths and soil formations. If drilling is easy and the equipment is in first class condition and if the line is being used at a reasonable factor of safety, then a relatively simple program may suffice. On the other hand, if drilling conditions impose heavy strains on the equipment and line, then the program should be developed on the basis of frequent moves and cuts.

A review of past and present day moving and cutting-off programs shows that a wide variation exists in practice. In one case it is found that line is slipped 5-ft twice, with 15-ft being cut off after the third slip. At the opposite extreme, no slips are made and from 200 to 500 ft is cut off each time. In view of the wide variation in moving and cutting-off programs as they exist today it is little wonder that the question of "how much to move and cut off" arises so often. The best way in which this question can be answered is through a study of how the line is destroyed, the nature of the destruction and the distribution of the resultant wear. It is hoped that the accompanying analysis and further development thereof will be of value in this respect.

Analysis of Bends and Destructive Forces

Fig. 1 is a schematic diagram showing typical string-up to consist of a length of wire rope, a number of sheaves, and a drum, the combination of which comprises a machine. Sheaves 2, 4, 6, and 8 are in the traveling block and 1, 3, 5, 7, and 9 are in the crown block. If the machine were to remain idle, then all component parts would remain intact until destroyed by corrosion or other exterior forces. The wire rope could be pounded and abraded and weakened to the point where it finally would break.

Consider the machine to be set in motion. In addition to pounding and abrasion, which work-hardens and embrittles the wires of the wire rope there is also bending, which fatigues them. Any section of the line that is subjected to maximum peening, abrasion and bending is the first part that develops cracked and broken wires.

An examination of retired rotary drilling lines that were just long enough for the string-up shows the maximum number of broken wires to exist somewhere past the mid-point of the line in the section closest to the dead end. Referring to Fig. 1, this is the section of line that falls somewhere between sheaves 2 and 6 when the traveling block is at the pick-up point or in Position 1. A study of the forces that act upon the line reveal not only the nature of the destruction, but also the distribution thereof over the entire length of line.

First, consider the length of line between the dead end and sheave No. 2 Due to the elasticity of the line this length contracts and expands under load, and consequently rolls back and forth over the dead sheave an undetermined number of times. As the degree of motion is relatively slight when compared to that of the balance of the line as it moves through the system, bending and pressures are concentrated at the two spots where the line makes contact with the dead sheave. Under drilling conditions where a great deal of vibration is set up, the combination of vibration, bending and pressure often results in permanent damage to the line at these spots. It is therefore important that under such conditions the line should be moved frequently.

Second, consider the various parts of the line between sheaves No. 2 and No. 9. If the traveling block is raised from position 1 to 2 the lengths of line between successive sheaves are bent a vari-

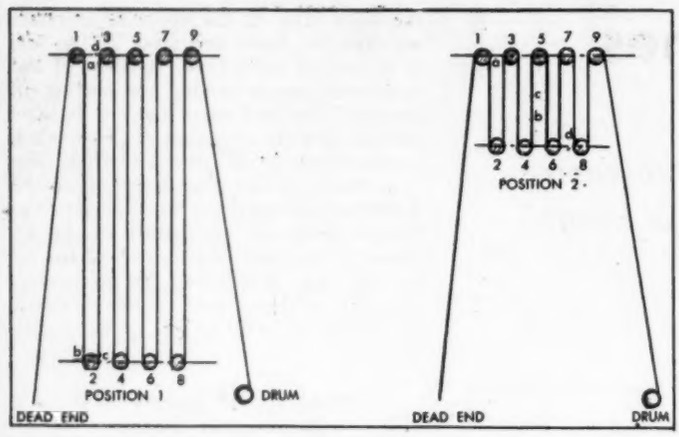

FIG. 1. Schematic diagram of typical string-up.

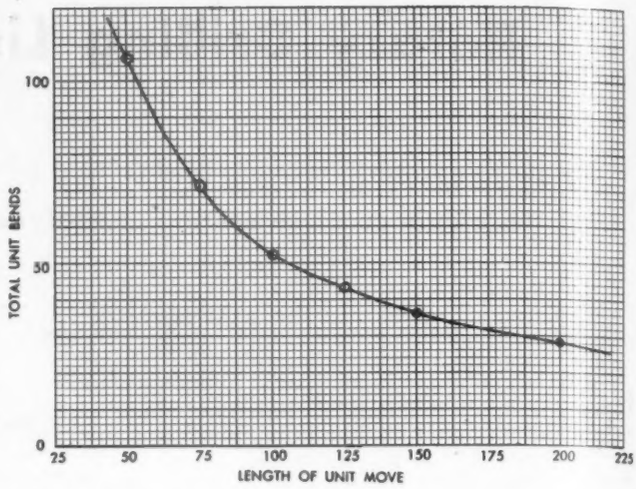

FIG. 2. Analysis of one operation.

Move	Total Unit Bends	Proportionate Bends
50	106	53
75	71	53
100	52	52
125	43	54
150	36	54
200	28	56

able number of times. The length between sheave 8 and 9 bends once over sheave 9. The length of line between sheave 7 and 8 bends over both sheaves 8 and 9 and consequently is subjected to two bends. In the same manner the lengths of line between sheaves 6 and 7, 5 and 6, 4 and 5 etc., are bent 3, 4, and 5 times, etc. The maximum number of bends will occur on some section between sheaves 2 and 3 with 7 bends resulting if the traveling block is raised to its highest point.

If the same analysis is made for a condition in which the traveling block is raised a distance of 1/3 the maximum travel, then again the number of bends can be determined for each section of the line.

Thus, each motion that the line makes can be studied and the number of bends that each section of line makes can be figured for unit cycle. If the bends that each section of line makes for two or more unit cycles are then totalled up, the location and distribution of the bends in a complex cycle can be determined.

A bend, as denoted here, means that the line has bent onto and then bent-off of a sheave. As any portion of the line that is winding onto the drum only makes a bend-on, the ratio of sheave bending to drum is 1 to ½. Any other portion of the line that has bent over more than one sheave and that may have accumulated up to 7 bends will also make only ½ a bend onto the drum. It may therefore be stated that if a particular length of line has made 7 bends over sheaves and ½ a bend onto a drum of the same diameter as the sheaves, that the ratio of sheave bending to drum bending is then 14 to 1, and that this sheave bending is a primary destructive force.

Another primary destructive force is a combination of peening and abrasion as it exists on the drum due to high pressures on the line as it scrubs against itself, crosses over underlying layers and steps up at the drum flange.

Any portion of the wire rope that passes both through the sheaves and onto the drum is therefore subjected to the maximum destructive force that is a combination of maximum bending plus maximum peening and abrasion. As most of the section of line between sheaves 2 and 6 not only passes over a maximum number of sheaves, but also winds onto the drum, it is the section subjected to the maximum destructive force and therefore is usually the section destroyed first.

Also from an analysis of the manner in which the line bends the total accumulation of bends for any given moving program can be determined.

As an example, if one unit cycle consists of simply raising the traveling block from its lowest position to its highest position and if for each unit cycle the line is moved so that the section between sheaves 1 and 2 is next moved so that it lies between sheaves 2 and 3, 3 and 4, 4 and 5 etc., then this section is subjected to 7 bends 6, 5, 4, 3, 2, and finally 1 bend for a total of 28. On the other hand if only half the amount of line is moved each time then the bends accumulate in the order of 7, 7, 6, 6, 5, 5, 4, 4, 3, 3, 2, 2, and 1, 1, for a total of 56. In either case, as the next following length of line also is subjected to the same moving cycle, it also accumulates the same total of bends. The accumulated total therefore becomes a constant and if the total bends for unit cycles become a constant, then the total bends for a complex cycle also become a constant. It is noted here that the build-up of constant bends occurs only when a unit length of line is moved at a unit periodic interval.

The results of such an analysis for one particular operation are shown in Fig. 2. The drilling cycle consisted of adding a single and taking off a threble; 136 ft standard derrick, 8 parts of line, distance from crown block to traveling block in pickup position, 120 ft.

By proportion it is found that the minimum number of bends occur for moves of about 100 ft. Also it is noted that the relative degree of proportionate bending only varies slightly from 50 to 150 ft.

The results of the entire analysis confirm certain basic principles.

1. For maximum service, the total length of line should be at least the length required for the string up plus the length in the traveling and crown block system.

This is true because the total of the accumulated bends does not become a constant until the length of line in the traveling and crown block system has been moved entirely through the system.

2. The only manner by which the destructive forces of bending, peening, and abrasion can be minimized is through a uniform distribution of wear over a longer length of line.

As wear caused by peening, abrasion and bending is concentrated at various spots on the line in the string up, unit lengths of line must be moved at a periodic uniform rate if the distribution of wear is to be uniform. Inversely, in terms of ton miles, moves or cuts are figured on the basis of so many ton miles per foot.

3. Lengths of moves or cuts must be such that spots of concentrated wear are not moved to other spots of concentrated wear.

As concentrated wear is greater than what may be called normal wear, a continued concentration of wear will result in rapid deterioration of the line over a relatively short length.

It must also be pointed out if line bearing pressures can be reduced through the use of larger sheaves and drums, not only will there be a reduction in wear due to peening and abrasion but there also will be less fatigue due to bending. The use of larger lines also results in lower line pressures besides allowing the lines to operate with a better load factor.

Abrasion can also be reduced by having the line well lubricated, especially on the drum, and by having grooved drums that make for better spooling. ★

Visiting During Mid-Continent's Breakfast for persons attending the Governor's Conference in Houston, Texas, recently, are: Mrs. J. S. Battle; Stone Wells of Tennessee Gas Transmission; Ken W. Davis, president, Mid-Continent; Governor J. S. Battle of Virginia; Mrs. Robert L. Dabney, Robert L. Dabney, assistant general manager of Houston Pipe Line Company; Mrs. Carter Lowance, and Carter Lowance, secretary to Governor Battle. Mid-Continent Supply Company was breakfast host for five mornings.

Israel Oil Prospects Said Favorable by Consultants

Max W. Ball and Douglas Ball, oil consultants to the government of Israel have announced that oil possibilities in some areas of that country are decidedly "good". American, Canadian, and Swiss oil companies are making inquiries on possible exploration and production, they announced.

A new law bill being studied by the parliament is reported to provide the most generous terms to oil men than that of any other foreign country, and compares generally with practice in the U. S., Max Ball reported, adding that he essentially had written the bill.

B of M Describes California Oil Recovery Methods

The recovery of oil in certain areas of California by secondary methods can be accomplished with economic success, according to a *Bureau of Mines* report.

Both existing pressure-maintenance and experimental water-flooding projects, together with laboratory investigations, conclusively show that stimulative procedures are economically sound in some sections of that state, the Bureau has found.

The material published in part of a two-part report titled, "Recovery of Oil in California by Secondary Methods," and describes gas-injection and water-injection investigations made in the Los Angeles Basin and Coastal oil fields by Bureau personnel during 1950 in cooperation with the oil industry. Part 1, which will be released shortly, deals with secondary recovery methods in the San Joaquin Valley oil fields.

The report describes the first investigations of secondary recovery methods ever made by the Bureau in California. Both parts of the report, which was written by A. G. Loomis and D. C. Crowell, petroleum engineers, and A. N. Fried, chemical engineer, compare the characteristics of California reservoirs with those of Mid-Continent and eastern fields, and discuss the problems associated with repressuring and water flooding. It points out economic value of secondary recovery by gas injection.

A free copy of Report of Investigations 4887, "Recovery of Oil in California by Secondary Methods—Part 2," can be obtained from the Bureau of Mines, Publication Distribution Section, 4800 Forbes Street, Pittsburgh 13, Pennsylvania.

Building Contract Awarded

The American Association of Petroleum Geologists announces the awarding of contract for construction of a headquarters office building in Tulsa, Oklahoma, at 15th Street and Boulder Avenue, about 10 blocks south of the main business district of the city.

Association business offices will be on the main floor. The building is designed for another floor, and there is also room for expansion on the lot.

The AAPG was founded in Tulsa in February, 1917, and the first published list showed 94 members, most of whom resided in Oklahoma, Texas, and Kansas. Present membership is over 9,000, with members located throughout the world.

Water Flood Project Planned

Carter Oil Company has announced plans to institute a pilot water flood to evaluate the secondary recovery possibilities of a 2900-acre block in the old Hogshooter stripper pool of Washington County, Oklahoma. At one time wells in the field, developed first from 1906 to 1913, produced in excess of 200 bbl daily but production has declined until at present total production from the field is less than 100 bbl daily from more than 100 wells.

Texas Oil Flow Sets New Record This Month

September crude allowables are setting a new record in Texas, with a boost of 261,201 bbl daily over the August permitted output. Texas Railroad Commission set the September allowable flow at 3,225,415 bbl. Increase is being accomplished by raising the number of producing days from 20 to 22.

Main reasons given for the increase were decline in crude oil stocks and forecasts of higher demand this winter for heating oils. The U. S. Bureau of Mines reports on U. S. stocks showed total crude oil stocks declined slightly more than 11,000,000 bbl in the six weeks prior to August 9, in spite of a sharp increase in Texas production last month. Most of the purchasing companies appearing before the Commission urged higher Texas output this month.

Survey of Oil Fields Out

Results of secondary oil recovery experiments in seven oil fields in the San Joaquin Valley of California are described in a Bureau of Mines report released by Secretary Oscar L. Chapman.

Part 1 of a two-part study, the report describes the Bureau's survey in the following oil fields: Rio Bravo, Elk Hills, Kettleman North Dome, North Coles Levee, South Coles Levee, North Belridge and Canal. Part 2 of the report, covering investigations of eight fields in the Los Angeles Basin and Coastal oil fields was published in May 1952. Writers of the report are A. G. Loomis and D. C. Crowell, petroleum engineers and A. N. Fried, chemical engineer.

A free copy of Report of Investigations 4886, "Recovery of Oil in California by Secondary Methods—Part 1" may be obtained from the Bureau of Mines, Publications Distribution Section, 4800 Forbes Street, Pittsburgh 13, Pennsylvania.

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North Dakota Has 40 Wells Since First Test in 1922

North Dakota had 40 producing oil wells and 60 dry holes since the first test well was drilled in 1922 with completion of 6 successful wells and 3 dry holes recently. The search for oil goes on despite the succession of wildcat failures outside of the Nesson anticline and in its three fields. Eighteen of the 60 dry holes were drilled this year so far. Assuming that one dry hole proves 160 acres non-productive, the 60 dry holes condemns only 9600 acres of North Dakota's 44,836,480.

During the month of July, North Dakota produced 113,081 bbl of crude, Amerada Petroleum Corporation and H. L. Hunt produced 113,081 bbl together. This compared with 84,000 bbl produced in June. Dr. Wilson M. Laird, state geologist, said that under the North Dakota Industrial Commission's ruling the wells could have produced more than 200,000 bbl a day, if they had had pipe line outlet under the 200 bbl a day allowable. He added that some wells reported did not produce for a full 30 days.

Downing Acquires Interest In Johnn Drilling Company

Hugh B. Downing has resigned his post as secretary-treasurer, Iverson Supply Company, Tulsa, Oklahoma, and has moved to Fort Worth where he has acquired an interest in the Johnn Drilling Company with main offices in the Electric Building, Fort Worth, Texas.

Before his association with Iverson Supply Company, Downing was connected with Oil Well Supply Company and Continental Supply Company. He is a graduate of the University of Arizona.

Johnn Drilling Company operates rotary rigs in West Texas and New Mexico. Officers of the company are:

Hugh B. Downing

Johney Cockburn, president; Hugh B. Downing, secretary-treasurer; Vernon E. Blain, vice president and drilling superintendent; E. E. Ray, director and tool pusher; O. G. Cheek, director and tool pusher, and J. W. Arnold, assistant secretary and treasurer.

Downing purchased an interest in this company from the estate of Ed Peters who was formerly vice president of Johnn Drilling Company.

—Photo by C. W. Flood

General Petroleum's extension well in North Cole Creek, Powder River Basin, Wyoming. A number of articles in this issue cover operations here.

More Than 300 Exhibits Set Permian Basin Oil Show

More than 300 exhibitors representing more than 600 manufacturers and service firms are expected at the second Permian Basin Oil Show to be held in Odessa, Texas, October 16 and 19. All indoor and outside space already has been reserved including that provided by a new 80 by 150 ft steel and concrete exhibit building. One of the biggest Oil Progress Week parades in the nation will launch the show.

Kilgore Well to Be Noted

East Texas will hold a 3-day oil celebration October 14-16, as a part of Oil Progress Week, in Kilgore, Texas. The celebration will be titled "Jube-Oil-Lee," a name suggested by J. M. Foster, Sun Oil employee. Feature of the event will be dedication of the L. D. Crim discovery well in the Kilgore area. General events will include barbecue, oil field bus tours, oil exhibits, fireworks and various contests.

Oil Survey Favorable Kenya Government Reports

The Government of Kenya has invited applications for oil and gas concessions in its northeastern Wajir-Mandera district.

This action of the British African territory was announced by the Mutual Security Agency, which aided the British and Kenya Governments in a geological survey of the Kenya district. The two-year survey was made by F. M. Ayers, senior geologist of the Department of Interior's Geological Survey and its dollar costs were paid from Marshall Plan funds by MSA's predecessor, the Economic Cooperation Administration.

Ayers' report, which is available for public inspection at Geological Survey offices in Washington, states that although no seepages of oil or gas are known in the area mapped, it appears to hold reasonably good petroleum prospects. The report advises test drilling and geophysical work along with more detailed mapping of the surface geology.

Sun Oil Builds New Production Laboratory

Sun Oil Company has added new quarters for scientific services here, a feature of the company's celebration of its 50th anniversary in the Southwest.

A large, modernized two-story building houses the new production laboratory, which, with 21,000 sq ft of space available, is five times as large as the total of the various former laboratories that are now housed under one roof.

This laboratory has a dual function. First, it acts as a service lab by rendering assistance on problems arising in drilling and production operations, evaluating results obtained and by recommending changes in operations.

Second, it serves as a center for research on the development of new products, instruments, and methods for improving drilling and production operations.

Saudi Arabian Output

Crude oil production in Saudi Arabia during July totaled 26,367,901 bbl, an average of 850,577 bbl daily according to the Arabian American Oil Company. This compared with 26,970,941 bbl in June, or an average of 899,031 bbl per day.

Crude oil production for the first seven months of this year amounted to 182,631,923 bbl, an average of 857,427 bbl daily.

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S12-3

Lion Oil Establishes New Operating Division

The formation of a new operating division of Lion Oil Company, to be known as the production and exploration division, has been announced by T. M. Martin, president. The functions of this new department will be to acquire, process, and develop oil and gas leases by combining the activities of the land, geological, and production departments, previously operated separately.

The headquarters of this new division and its staff will be at the company's home office in El Dorado, Arkansas, where John E. Howell, vice president, will direct the division as its general manager. Frank Richardson will act as Howell's assistant, with the title of assistant general manager of the division; and the staff will be composed of R. T. Ellzey, as manager of land; E. D. Klinger, as chief geologist; and F. E. Steele, as general superintendent of production.

The operating area of the company's new division will be divided into four regions, each of which will be headed by a regional manager. The Rocky Mountain region, consisting of Rocky Mountain and Williston Basin areas, will be at Denver, Colorado, under the management of C. L. McArthur. The Southwestern region, consisting of New Mexico, North-Central Texas, Panhandle and West Texas areas, will have offices at Midland, Texas, under the management of F. H. McGuigan. The central region, consisting of Oklahoma, Kansas, and Nebraska, will have its headquarters at Wichita, Kansas, with R. I. Williams as regional manager. Headquarters for the southern region, comprised of Arkansas, Louisiana, Mississippi, Alabama, and Gulf Coast and East Texas areas of Texas, will be at Shreveport, Louisiana, under Bert. E. Gamble as manager.

Steel Strike Effects Are Still Felt in Oil Industry

Cuts in production of oil-country tubular goods because of the steel strike has set back the government's goal for 1952 by about 9000 units, according to J. Ed Warren, Deputy Petroleum Administrator.

In North Dakota the state industrial commission has temporarily eased a regulation to allow the use of less tubing in completing oil wells. The commission amended the regulation to provide a minimum of 500 ft of tubing to be used, effective until April, 1953. This compares with the present practice of running tubing 8300 to 8500 ft.

Canadian drillers report that effects of the strike will be felt for two or three months, as it will take steel production that long to build back up to normal, and to reach western Canada. During one week last month, 90 rigs of 250 were idle due to lack of steel. Oil drilling contractors have been buying steel pipe from Japan, France, Germany. The Netherlands, and Belgium.

Texas Railroad Commission listed 265 requests to drill in the week ended July 26, 67 down from week before. For the year the figure is 12,076, off 1338.

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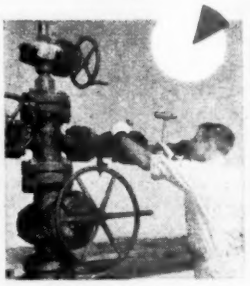
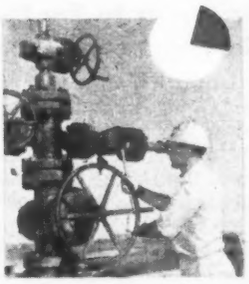
RIGHT ON THE TREE

IN ONE HOUR!

1&2 Bleeding pressure out of valve (top) and out of packing gland (above).



3 Removing bonnet clamp ring.

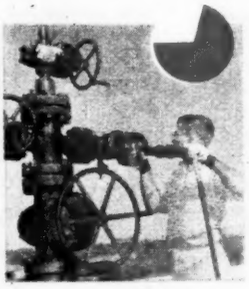


4 Removing bonnet seal ring.

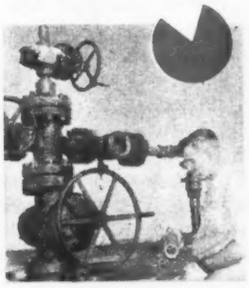
5 Removing bonnet, gate and segment.

6 Breaking seats loose.

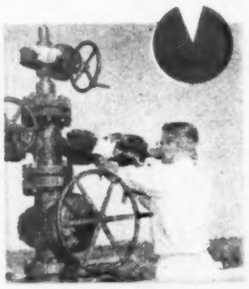
7 Removing worn seats.



8 Installing new seats.

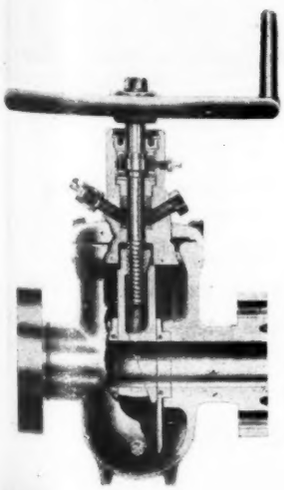


9 Installing new gate and segment.



10 Replacing stem, bonnet and bonnet seal ring.

11 Replacing clamp ring and the job is done. Elapsed time one hour.



●The above photographs illustrate how simple it is to overhaul a W-K-M Valve on the tree. When overhauled as shown, the valve becomes as good as new, ready for many more years of efficient trouble-free service.

There is no need to go into great detail to point out the advantages and economies of on-the-spot repair—it is self evident that even the least valve on a tree can raise hob with production if it cannot be repaired or replaced in the shortest possible time.

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News

Construction Resumed on Seamless Mill Pipe

Colorado Fuel and Iron Corporation has announced that construction work has been resumed on its new seamless pipe mill being built at its Pueblo, Colorado plant. Construction of the pipe mill was suspended during the steel strike.

The company still anticipates that this mill may be completed in the first half of 1953. The mill will have an anual capacity of approximately 150,000 tons of finished pipe and tubing when rolling an average range of sizes. Seamless pipe to be produced at this new mill will supply primarily the oil and gas industry in the western and southwestern states.

Speakers and Officials at the August meeting of Los Angeles Chapter of Nomads were: Bill Sargent of Sargent Engineering Corporation, chairman of entertainment committee; Alex Gaal, vice president of Earle M. Jorgensen Company, speaker; Bill Wilson of Web Wilson Oil Tools, chapter president; Bill John, manager of the Los Angeles Rams.

Atlantic Wants to Try New Secondary Recovery Method

The Atlantic Refining Company has asked the Texas Railroad Commission for permission to try a new method of secondary recovery in the Spraberry sand zone of the Driver field, Glasscock and Midland counties. New method calls for injection of water into the Spraberry in imbition displacement test through three wells, to saturate an area of about one mile around each well. Atlantic claimed that conventional water injection would create channeling.

Kuwait Field Output Up

At the end of the first six months this year, the Burgan field in the Persian Gulf Sheikhdom of Kuwait had produced 18,200,000 tons, (approximately 127,400,000 bbl) of crude oil, a 66.9 per cent increase of the first six months of 1951. The Burgan field concession is owned by Gulf Oil Corporation and Anglo-Iranian Oil. June output totaled 3,100,000 tons (21,700,000 bbl), compared with 2,100,000 tons (14,700,000 bbl) for June of 1951.

Delhi Field Unitized

Louisiana's largest conservation project in its oil history was begun recently when operators in the Delhi field, Franklin Parish, signed an operating agreement for unitization. Operators are Gulf Refining, Murphy Corporation, and Sun Oil Company, with Murphy and Sun the largest operators.

SACROC Unitization Plan

The Scurry Area Canyon Reef Operators Committee has completed plans to unitize 1229 oil wells on more than 47,000 acres in Scurry County, Texas. The Kelley-Snyder and Diamond "M" fields were discovered late in 1948 and are virtually completely drilled up on the spacing pattern at the present time. One of the main factors that makes unitization under pressure maintenance desirable is that bottom hole pressure has dropped from 3122 lb in 1948 to 1675 lb at the present time. In the meantime the gas-oil ratio has increased from 870 cu ft of gas per barrel to 1163 cu ft per barrel indicating a real need for conservation measures at this time. Some 108,597 bbl per day were produced at the peak point in 1950 but proration under maximum efficiency rate of production, now set at 100 bbl per day, has seen this drop to about 80,000 bbl per day. Engineers estimate the present production methods will recover less than one-half billion barrels of oil but that two and one-half times this amount, or more than one billion barrels of oil, can be produced during the next 40 years for benefit of royalty interests and lessees alike under the proposed plan.

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Ever since Jensen started making pumping equipment over 33 years ago, they have always worked hand-in-hand with the oil man. They worked out their problems together. The reputation enjoyed by Jensen Units today is the result of this fellowship and cooperation.

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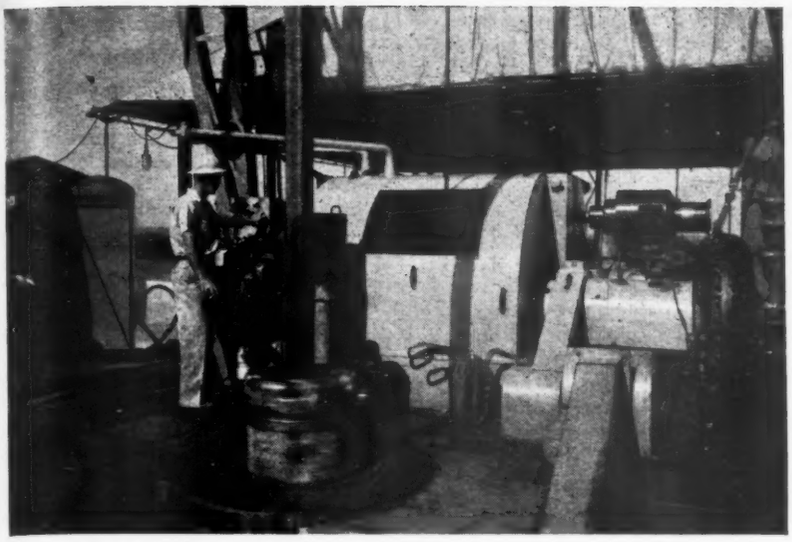
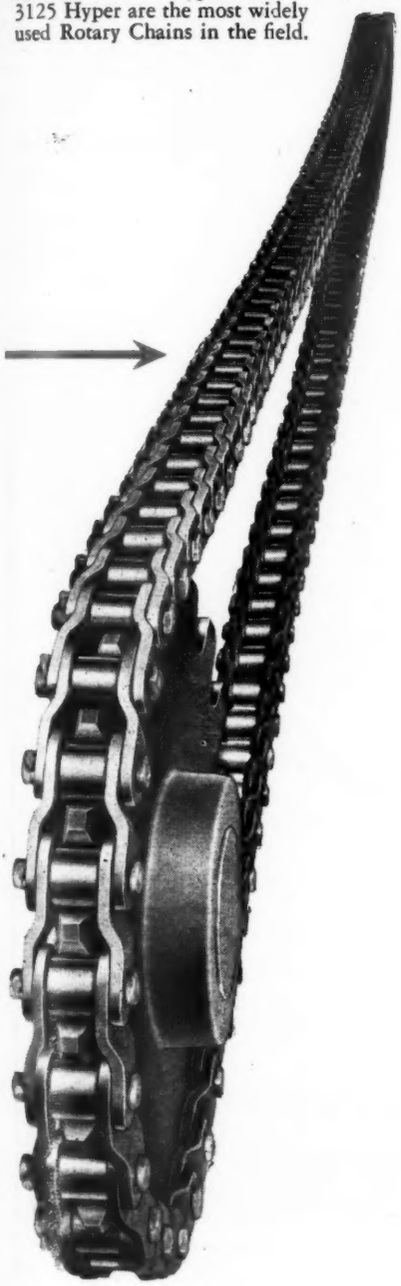
Brochure and References on Request



Link-Belt SS-40 Hyper and SS-3125 Hyper are the most widely used Rotary Chains in the field.

There's Unsurpassed Hole-Making Capacity in this Rotary Chain



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Link-Belt API Chain (SS Type) is the strongest and most dependable chain made for rotary service. It has proved its unsurpassed ability to give long, trouble-free service on rigs the world over.

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API CHAINS (SS Type)

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San Juan Oil Organizes New Consulting Firm

The San Juan Oil Company of Dallas, Texas, which manages and operates some 550 oil wells for five corporations, has enlarged its activities by organizing a new petroleum consulting firm.

With a staff of 12 professionally trained men, the new technical firm, Bradley, Crichton and Associates, will be one of the largest in its specialized field. Beginning immediately, Bradley, Crichton, and Associates offer their services to the industry in all phases of consultation and evaluation. Offices are at 903 Employers Insurance Building, Dallas.

The consulting staff will be under the immediate supervision of John A. (Jack) Crichton, former vice president and director of De Golyer and MacNaughton, and prior to that, geologist and engineer with Union Producing Company.

Shell's Montana Offices Are Officially Opened

New and enlarged offices in Billings, Montana, from which Shell Oil Company will direct its widening search for oil in that state were shown to leading citizens of this area recently. The new headquarters of Shell's Billings district office is on the fourth floor of the Hart-Albin Building and allows the company to combine several offices previously maintained in different locations in the city. S. F. Bowlby, vice president, pointed out that the Billings office was only opened in early 1950; however, the expansion of operations that followed Shell's discovery of the first producing well in the Montana portion of the Williston Basin at Richey on July 13, 1951, soon necessitated the acquisition of the new offices.

Bowlby welcomed visitors to the open house, along with division manager J. E. Clark from Casper, Wyoming, district geologist T. R. Barnes, and district landman H. M. Walley, who are in charge of Shell's operations in Billings.

Bowlby revealed Shell, in the last 10 years, has spent more than $40,000,000 for its search for oil in the Rockies and Dakotas, and is now increasing its expenditures in this region to upwards of $15,000,000 annually.

"Thus far, we have taken less than 100,000 barrels of oil from this vast area in return for our investment," Bowlby stated. "We believe, however, the quantity of oil produced in this area in years to come will compensate us for our willingness now to channel millions of dollars into the quest for new petroleum reserves."

At the present time, Shell has 65 employees working in the 7500 sq ft of space in the new offices, in addition to the substantial number of personnel assigned in the field under the jurisdiction of Barnes. Shell now has eight drilling rigs operating in the Rockies, six of which are in Montana. Of the eight wells being drilled, five are development wells and the remaining three, wildcats.

Headquarters Announced For 1953 AAPG Meet

The New Statler Hotel, Los Angeles, has been chosen as headquarters for the 1953 annual regional meeting of the Pacific Coast Section, Society of Exploration Geophysicists on October 30 and 31, it was announced by Wallace L. Matjasic, of Honolulu Oil Corporation, president of the section and chairman of arrangements for the SEG. As in the past, this will be a joint meeting of the Pacific Coast sections of The American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists, and Society of Exploration Geophysicists.

President of the Pacific Coast section of AAPG is Homer J. Steiny, of Tide Water Associated Oil Company, Los Angeles, and W. Thomas Rothwell, of Richfield Oil, is president of the SEPM section. T. H. Braun, of Superior Oil, Pasadena, and Southern district vice president of the SEG Pacific section, is in charge of the technical program for geophysics.

Delhi Opens Montana Office

Delhi Oil Corporation of Dallas, Texas, has opened offices in the General Custer Hotel in Billings, Montana. Delhi landman in the Williston Basin is Bill Carey. Other Delhi personnel include: Harrell Budd, geologist; A. J. Newton, party chief of company geophysical crews, and Don Lohrentz, seismologist.

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Costly pump repairs - - - ?
Lost production - - - - ?

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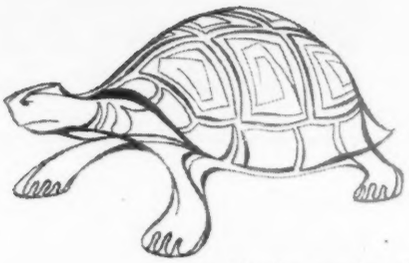
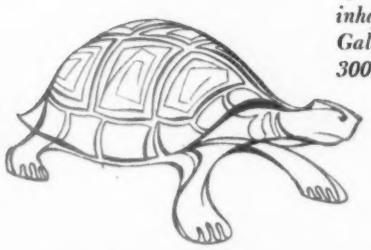


• *No other member of the turtle family (in fact no other living creature) can match the life expectancy of the species inhabiting the waters of the Galapagos Islands. Average life: 300 to 400 years.*



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Safer way is to look for the name AETNA on the bearings you buy for replacement in the equipment you use—to specify AETNAS when blueprinting a brighter future for the equipment you make. Indicative of their quality and lasting serviceability is the fact that 80% of our business comes from firms we have served for 20 or more of our 36 years.

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What's Doing in Drilling

First Oil Brought in In Texas Gas Field

The Texas Company announced the first oil discovery well in the Finfrock field, Harris County, Texas, upon the completion of the H. D. Taylor No. 1, three miles southeast of Katy, as a producer. Flowing through perforations at 6874-6877 ft, the well was gaged on an 11-hr test as having the rate of 105 bbl daily through a 10/64-in. choke. The gas-oil ratio was reported 540 to one.

The Taylor No. 1 is producing from the Yegua, the same sand from which two gas wells in Finfrock field are producing. They are approximately half mile southwest of the new well. Nearest oil production is in Fulshear field, Fort Bend County, about one and half miles southwest of the Taylor No. 1.

Alberta Gas Area Extended

Canadian Fina Oil, Ltd., Royalite Oil Company, Ltd., and associates have indicated a 3½-mile westward extension to the Gordondale gas discovery in the Peace River gas export area of northwestern Alberta. Gordondale No. 3 well found gas rated at 2,500,000 cu ft daily on a test of 2470 to 2485 ft and 2,500,000 at 2483 to 2490 ft.

Elk City Field Given Southeast Extension

E. Constantin, Jr., of Dallas, Texas, has a good well at the No. 2 Lester in Washita County, Oklahoma, a step-out north of the southeast extension of the Greater Elk City field. The well is northeast of big condensate production. On a 1-hr drillstem test, of sandy zone at 9928 to 10,000 ft, with the well kicking out the 1800-ft water blanket immediately, 40-deg gravity oil flowed at the rate of 50 bbl an hour. Gas was estimated at 1,500,000 cu ft daily.

Kansas Pool Extended

Cities Service Oil Company (Delaware) extended the Southeast Benson pool of Pawnee County, Kansas, to the southwest with the completion of its Becker B No. 4 for 3000 bbl of oil and no water daily. The well is flowing from Lansing-Kansas City, which was topped at 3579 ft.

Shell Gets Good Well In Ely City Oil Field

Shell Oil Company has a new well in the Beckham County, Oklahoma, sector of the Elk City field. It is the company's No. 2 Hutton "B" which flowed 553 bbl of 47.7 gravity oil in 24 hr through a 22/64-in. choke from perforations between 9972-96 ft. Gas-oil ratio was 1550 to 1. On drillstem test of perforations between 10,057-72 ft, with one-half inch top and bottom chokes, the well flowed 1146 bbl of 45.3 oil in 22 hr.

Shell Completes Prolific Williston Basin Well

Shell Oil Company has completed what may prove to be the largest producer in the three-state Williston Basin. It is the company's No. 42-24E Beery in the Richey field of McCone County, Montana. The well flowed at the rate of 5300 bbl daily on basis of a 5-hr open flow, from perforated zone at 7150-75 ft. Formation was washed with 1000 gal of acid. Oil tested 38 deg gravity.

Sinclair May Extend Golden Trend Area

Sinclair Oil and Gas Corporation has announced that its No. 1 Community Willie Smith, McClain County, Oklahoma, may extend the Golden Trend area to the northeast to meet the Northeast Bradley field near the Grady County line. On a drillstem test lasting 1½ hr, the well gas gaged 1,030,000 cu ft a day, recovery was 360 ft of 50.6 gravity condensate with 1000 ft of mud and water, cut with condensate. The well is scheduled for a depth of 12,500 ft.

Phillips' Well Complete

Phillips Petroleum Company has announced that its No. 1 Creel in Stephens County, Oklahoma, flowed 77 bbl of 36.1 gravity oil in 2 hr through a ¼-in. choke from perforations in the Humphries sand between 6892-6947 ft. In the lower Sims sand perforations between 6964-7002 ft, plugged back depth was 8462 ft.

Two Wyoming Wells Completed by Sinclair

Two new wells have been completed in Wyoming by Sinclair Oil and Gas Company. In Fremont County, the No. 10 Happy Springs flowed 1536 bbl of 37 gravity oil in 24 hr. The flow came from 4488 to 4543 ft in the Dakota sand. In Natrona County, the company brought in its No. 7 East Salt Creek Unit A from a depth of 6004 to 6051 ft in the Dakota sand. It gave a 24-hr flow of 439 bbl of 33 gravity oil. Tests at 4992 to 5024 ft brought 225 bbl of 36 gravity oil from the Wall Creek sand. The well, sixth producer in the field, will be completed dually from both depths.

West Texas Field Extended

Gulf Oil Corporation has extended the Triple N (Ellenburger) field of Andrews County, West Texas with completion of its No. 1-000 University for a daily flow of 986.41 bbl of 48 gravity oil, no water, with gas-oil ratio of 524-1. Production is through a ¼-in. tubing choke and perforations are between 12,470-12,570 ft, after acidizing with 1000 gal. Flowing tubing pressure was 1200 lb.

Canada Gets Big Gas Well

A potential of 14,000,000 cu ft of gas daily has been given Canadian Delhi Oils, Ltd., at its Minnehik No. 1 well 30 miles west of Alberta's Pigeon Lake area. The well is a Madison formation wet gas discovery.

Preventing Unauthorized Parking on Lease

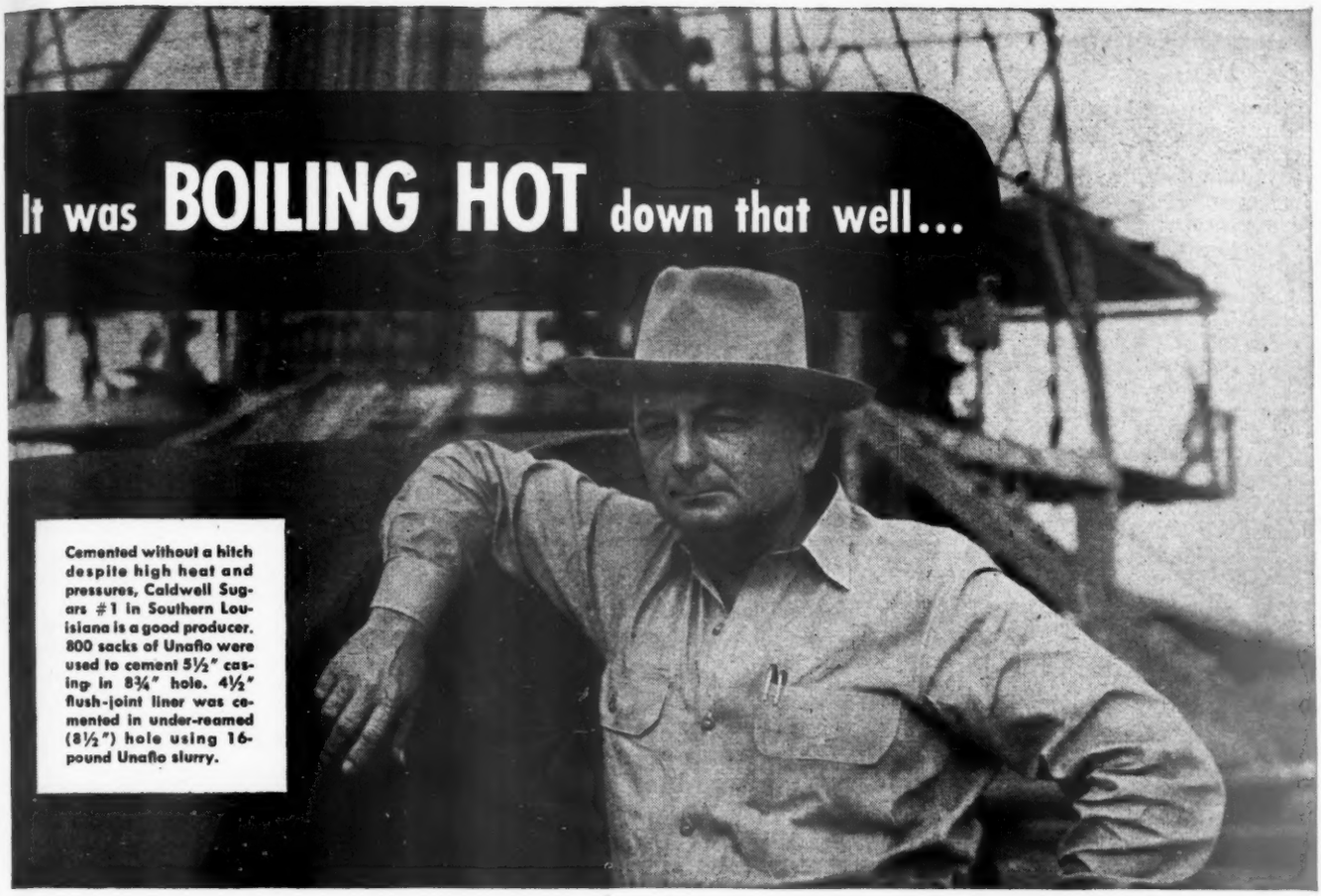
Bars of 2½-in. pipe close roadway across cattle-guard.

Although the cattle-guard effectively restricts live stock, it does not prevent unauthorized entry on a lease, with consequent hazard to the oil company's equipment.

One company uses two bars, of 2½-in. pipe, to close the roadway across the cattle-guard, fitting short flat steel ends to the pipe with slots to receive a padlock. Keys permit the landowner and lease workers to enter at will.

The pipe bars are carried on short sections of 4-in. pipe which, in turn, are carried between collars welded to the 3½-in. uprights at the ends of the open guard.

The bars, when released from the padlock, may be swung clear of the drive area; but, being retained between collars, cannot be carried away or mislaid.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Cemented without a hitch despite high heat and pressures, Caldwell Sugars #1 in Southern Louisiana is a good producer. 800 sacks of Unaflo were used to cement 5½" casing in 8¾" hole. 4½" flush-joint liner was cemented in under-reamed (8½") hole using 16-pound Unaflo slurry.

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says Area Superintendent Bob Bennett, of F. A. Callery, Inc., Houston, Tex.

THAT 14,014' WELL hit 230° Fahrenheit . . . pressure over 6100 p.s.i. But after a casing and liner job with Unaflo Oil-Well Cement, the formation would not break down under 6000 p.s.i. pump pressure preliminary to a squeeze. That's one reason why Superintendent Bennett is sold on Unaflo.

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Drilling

Union Oil Gets Two New Wells in California

Union Oil Company of California has two new wells in the Santa Clara Valley northwest of Los Angeles. They are Torrey 84 and Oakridge 2-10, and are producing from the Sespe sand. A. C. Rubel, vice president for exploration and production of Union Oil, has declared that these wells may be the "biggest thing Union has had in many, many years." The Torrey 84 came in flowing at intervals at the rate of 440 bbl of 19 gravity crude daily from 9944 ft, but after being put on the pump it is expected to do much better, Rubel reported. The thickest Sespe sands ever found in the state were found in the well.

Oakridge 2-10, a new discovery, is pumping at the rate of 368 bbl of oil a day, from a new zone known as the "Luisian" in the middle Miocene. Gravity is 23 deg. Producing interval is from 2850 to 3300, total depth.

Reworked Wildcat Flowing

A reworked wildcat, owned by F. A. Gillespie and Sons, George W. Deck, and Fordee-Rhoades Oil Company, is producing from the second Wilcox production at the No. 1 Hempken in Garfield County, Oklahoma. The well flowed 9 bbl of oil per hour from the second Wilcox between 6165 and 6178 ft. The strike flowed 5,250,000 cu ft gas per day along with 80 bbl of distillate per 1,000,000 cu ft of gas from interval between 5455 and 5488 ft in the Mississippi.

Amerada Stakes New Well In Beaver Lodge Field

Amerada Petroleum Corporation has announced that it has staked another test in the Beaver Lodge Madison field of Williams County, North Dakota. This company already has 26 wells in the field, averaging 3600 bbl of oil a day under heavy pipe line restrictions. New test is the No. 1 Johnson. Newest well is the No. 1 Nelson, which flowed 375 bbl of oil in 24 hr from a plugged back depth of 8430 ft.

Amerada Well Flows 121 Bbl of Oil Per Day

Amerada Petroleum Company recently completed a flowing well in the Milroy pool of Stephens County, Oklahoma, its No. 1 Smith. The well flowed 121 bbl of oil per day through a 14/64-in. choke, and was completed from perforations at 4325-45 ft, with a plug-back depth of 4374 ft. Hole was bottomed at 4432 ft, and 5½-in. casing was set at 4420 ft.

Deep Rock Discovery Made

Deep Rock Oil Company has a new discovery for Beaver County, Oklahoma, at its No. 1 Shadden-A. On a 1-hr drillstem test made at 7318-32 ft, 180 ft of free oil from the Morrow sand, and 30 ft of oil and gas-cut mud were recovered. It is being drilled ahead below 7351 ft on contract to 9850 ft at this time.

Rotary rigs operating in oil fields of United States and Canada.*

Weeks	Total	Gulf Coast	Pacific Coast	Illinois Oklahoma Kansas	Rocky Mountain Canada	West Texas New Mexico	Arkansas Louisiana Texas	North Texas
(July)								
Second	2700	564	162	593	407	537	144	293
Third	2611	523	161	590	395	511	138	293
Fourth	2521	523	158	566	382	488	133	272
(August)								
First	2536	527	155	566	400	481	133	274
Second	2535	524	155	577	404	469	130	276
Third	2478	512	157	571	384	461	122	271

* As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

Sinclair Opens New Gas Zone

Sinclair Oil and Gas Company's No. 1 Community Smith in the North Lindsay field of McClain County, Oklahoma, is apparently opening a new gas zone in the field. On a drillstem test at 11,048-78 ft, gas showed in 22 min at an estimated rate of 4,650,000 cu ft per day. Oil flow began in 43 min at the rate of 5 bbl an hour. When tool was pulled 950 ft of 47 gravity oil and 50 ft of oil and gas-cut mud were recovered. At the present time the crew is drilling ahead below 11,090 ft.

Two Wells Completed In Kansas' Maes Field

The Maes field in Ellsworth County, Kansas, has two new oil wells of 3000 bbl daily. One is the No. 2 Janses, drilled by El Dorado Refining Company, which is producing from the Arbuckle, bottomed at 3302 ft. The other is the No. 1-A Gray, which is drilled by Grant Oil Company. This well is also producing from the Arbuckle at 3262 ft, total depth.

Montana Test Well Staked

Union Oil Company of California announced that it has let a contract as operator for the immediate drilling of an 8600-ft prospect well in Daniels County, Montana, for the joint account of Los Nietos Company, Signal Oil and Gas Company, and Hancock Oil Company. Location for the well, to be known as Union-Hancock-Signal-Otto Neubring No. 1, has been staked in the center of the northwest of the Northeast of Section 32, Township 35 North, Range 47 East. This is the first test to be drilled by the partnership to test their extensive holdings in the Eastern Montana portion of the Williston Basin. Other exploratory wells are contemplated for this area in the near future.

New Producing Area Given Chitwood Pool

Pure Oil Company and Kidd Williams Drilling have reported that their No. 1 Thompson unit, has extended the Chitwood unitized pool to the south, as well as discovered a new producing zone for that field. The new well flowed 992 bbl of 39.7 gravity oil in 24 hr, using a 24/64-in. choke. Gas gaged 3,000,000 cu ft a day. New sand zone is the Boatwright sand, which heretofore produced gas-distillate in the unit field and the Boatwright sand in open hole at 12,361 to 12,416 ft, the total depth.

Cities Service Confirms Kansas Pool Production

Cities Service Oil Company (Delaware) confirmed production in the Oscar West pool of Stafford County, Kansas, with the completion of its Smith "M" No. 1 for 2405 bbl of oil, no water, in 24 hours from the Kansas City limestone. At a total depth of 3800 ft, potential was established on flow through ⅜-in. choke from perforations at 3579 to 3596 ft after a 2000 gal acid treatment. The Lansing-Kansas City was topped at 3460 ft, Viola at 3745 ft.

Louisiana Field Given New Sunray Producer

Sunray Oil Corporation has announced completion of the No. 1 Cyprien Fontenot extension well of the West Branch field in Acadia Parish, Louisiana. The well produced at the rate of 13,000,000 cu ft of natural gas and 89 bbl of gas-distillate per day. The well was drilled to 12,600 ft and plugged back to 11,210 ft and the potential was taken on a 3¼-hr test through perforations at 11,196 to 11,206 ft through an 8/64-in. choke. Field discovery well was Sunray's No. 1 Fred Loewer, one mile east of the new well.

Texas Eastern Production Extends Louisiana Field

The East Haynesville field of Claiborne Parish, North Louisiana, has been extended with completion of the gas-distillate well drilled by Texas Eastern Production Company and others. The well, No. 1 Burnham unit, flowed 194 bbl of 66.5 gravity distillate with 1,446,000 cu ft of gas, through a 12/64-in. choke, of official 24-hr potential test. The well was completed from the Burne zone in a section from 10,340 to 10,394 ft, with casing set at 10,340 ft. Tubing pressure on the test was 3650 lb, casing pressure was 3850 lb, and gas-oil ratio was 7457 to 1.

Stanolind Adds New Well To Oklahoma's Milroy Pool

Stanolind Oil and Gas has added a new well to the Milroy pool of Stephens County, Oklahoma, with completion of its No. 2 Brown-B. The well had an estimated daily potential of 250 bbl of 32 gravity oil, and gas-oil ratio of 500-1, with a plug-back depth of 3770 ft and perforations in a series from 3204 to 3748 ft.

Total depth was 3825 ft, with 7-in. casing landed at 3802 ft.

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Exploration Activities

AAPG Announces Nominees

Morgan J. Davis, president of the American Association of Petroleum Geologists, announces the report of the nominating committee, with the following candidates for executive offices of the Association for 1953-54: President, John Emery Adams, Standard Oil Texas, Midland, and Jesse V. Howell, consulting geologist, Tulsa; for vice president, Glenn C. Clark, Continental Oil, Oklahoma City, and Leslie M. Clark, Pacific Petroleum, Ltd., Calgary, Alberta, Canada; for secretary-treasurer, Clarence E. Brehm, consulting geologist, Mt. Vernon, Illinois, and Elliott H. Powers, Southern Production Company, Fort Worth, Texas; for editor of the Association's monthly Bulletin of Petroleum Geology, George V. Cohee, United States Geological Survey, Washington, D. C., and Armand J. Eardley, University of Utah, Salt Lake City.

In making this announcement, Mr. Davis points out that additional nominations may be made by written petition of fifty or more A.A.P.G. members received at Association headquarters in Tulsa, not later than November 15, 1952.

Texaco Pool Opener Seen in Williston Basin Area

The Texas Company has indications of a new oil pool in the Williston Basin at its NCT 4 No. 1 in Dawson County, Montana. The company has recovered 2880 ft of light green 40 gravity oil in a drillstem test of the Ordovician formation from between 10,004-10,100 ft. Ordovician formation was topped at 9274 ft, placing the producing zone about 800 ft below the top of the formation. Gas, estimated at about 58,000 cu ft daily, came to the surface in 20 min with tester open 2 hr, and 540 ft of oil-and-gas-cut mud were recovered, 75 per cent oil, plus the 2880 ft of clean greenish 40 gravity oil. The well is coring ahead past 10,100 ft.

Good Oil Shows Seen at Beaver, Oklahoma, Well

Carter Oil Company's No. 1 Dorman C in Beaver County, Oklahoma, may prove to be an exceptionally good well, according to a report from the company. The new well swabbed 72 bbl of oil, without any water, in 13 hr through tubing, from a plugged back depth of 5660 ft. It flowed 290 bbl of oil in 4½ hr through a ¾-in. choke, without any water, after being treated with 100 gal of acid.

Offshore Well Below 7400 Ft

Drilling below 7400 ft is the No. 1 State of Mississippi, the state's first offshore oil exploration. The venture is being made jointly with Gulf Refining Company, and Melben Oil Company.

Gas Flow Seen in Utah Test

First substantial show of gas was reported in the Cities Service Oil Company Peters Point No. 1 wildcat in Carbon County, Utah. The rank Uinta basin test produced at the rate of 1,140,000 cu ft of gas daily in a drillstem test in the Wasatch sandstone from 2844 to 2900 ft. Production was through a one inch bottom hole choke and a one-half inch top choke. Operators are coring ahead below 2900 ft.

Measurable quantities of gas had been gaged on two previous drillstem tests, although the volume was small.

The wildcat is 60 miles southwest of Vernal and 125 miles southeast of Salt Lake City. Nearest oil production is 35 miles northwest of the test.

Production Opened in Third North Dakota County

A third county has been found productive in North Dakota, with the new well, Amerada Petroleum Corporation's Clifford Hanson No. 1 being the biggest flow to date. Latest county to be found oil productive is Montrail County, where the new Amerada well has flowed 63 bbl of oil an hour during a 3-hr, 20-min drillstem test of the Madison limestone from 8118 to 8164 ft. Gas production has been gaged at 2,841,000 cu ft for four hours, highest pressure to date in the Madison wells. Record natural flow had previously been Amerada's Dilland No. 1 in Beaver Lodge Madison pool.

Oil Found in Canadian Test

Socony-Vacuum Oil Company has announced that oil has been encountered in a new wildcat in southwestern Saskatchewan. The well is known as Socony-Western Prairie Success 3-6B. It is about seven miles northeast of the recently discovered Cantuar field, which now has two producers, and it is about 10 miles due east of the Fosterton field.

On a one-hour drillstem test of the interval 3097 to 3110 ft, (Lower Cretaceous), the well flowed gas to the surface in 19 min and pipe recovery consisted of 551 ft of 22.6 gravity oil.

New Gas Well Brought In

A new gas well has been brought in 60 miles southwest of New Orleans, Louisiana, by Phillips Petroleum Company. It is the company's No. 2 Continental Fur, which had an estimated open flow of 39,000,000 cu ft from perforations at 9372-76 ft from perforations at 9372-76 ft.

Richfield Makes New Discovery in California

Richfield Oil Corporation has a new wildcat well, its Denlinger No. 1 in Fresno County, California. The well, situated in the Turk Anticline area, produced gas at an estimated rate of 9,356,000 cu ft daily and 54.5 gravity condensate at 141 bbl daily in a formation test at 9243-308 ft. Nearest production is 10 miles north in the Coalinga field.

Diesel tractor with bulldozer is clearing and leveling a heavily timbered area for new gas well drilling location south of Oakwood, Texas.

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Exploration Activities

First Mesa Verda Flow Hit in Wyoming County

Stanolind Oil and Gas Company's No. 1 Unit in Sweetwater County, Wyoming, has given the Green River Basin its first production from the Mesa Verde formation. Stanolind recovered 1400 ft of free oil and 400 ft of water in a 2-hr test of the Mesa Verde sand at 6532-54-ft.

Tide Water Well Completed

Tide Water Associated is completing its No. 1 H. T. Monteith in Lea County, New Mexico, two miles north of the Lovington field. The well was given a preliminary gage of 148 bbl in 3 hr through ½-in. choke following acid treatment through perforations at 11,256-80 ft. Tubing pressure was 630 lb.

Canadian Test Well Set

Cities Service Oil Company (Delaware) has announced location of a Canadian test well, Lubican River No. 1, in the province of Alberta. The location is approximately 75 miles east of the town of Peace River and 175 miles northwest of Edmonton on a company exploratory reservation comprising 99,840 acres. Principal objectives are Cretaceous sandstones and Mississippian and Devonian limestones. Operators expect to drill to Granite at 5500 ft.

Kentucky Oil Pool Open

C. B. Mansfield has completed his No. 1 R. L. Latta in Henderson County, Kentucky, to open the Midway West pool. The well was completed in the McClosky limestone at 2568-74 ft. Plug back total depth is 2574 ft. Initial production was 75 bbl of oil and 30 bbl of water in 24 hr.

Gas-Distillate Discovery

An oil producing well has been brought in about one mile from a gas-distillate discovery in Hidalgo County, Texas, by Houston Oil Company of Texas and American Republics Corporation jointly. The companies' Temple W. West No. 2 was given a 24-hr potential test, and flowed 713 bbl of 45.6 gravity oil through 10/64-in. choke. Tubing pressure was 1200 lb and gas-oil ratio 682-1. Plugged back depth is 6263 ft, and flow is from a Vicksburg sand.

Kansas Discoveries Reported

A new discovery has been made in Rice County, Kansas, at Birmingham and Bartlett's No. 1 Fergueson, a mile northeast of the Geneseo pool.

Another discovery was made in Rooks County, by Champlin Refining Company at its No. 1 Brungardt. It is rated at 223 bbl daily.

Kansas Discovery Made

Petroleum, Inc., has reported its third oil discovery in two weeks in Stafford County, Kansas. It is the company's No. 1 Stroble "C" drilled in the Simpson sand at 3852-60 ft. It recovered 305 ft of free oil and 60 ft of oil cut mud during a one-hour drillstem test at 3854-61 ft. Flow is from the Arbuckle formation.

Oil Indications Seen in Peace River Area Well

Pacific-Gas Exploration Rycroft No. 1 in the Peace River area of Alberta has found large gas flows and some oil indications in Cadomin sand formation.

The well, now rated as a large new discovery, is in the area dedicated to the export of natural gas through the Westcoast Transmission Company, Ltd., pipe line to the Pacific Northwest. More than 45 ft of gas and oil pay zone has been opened in the Cadomin sand. The well is now drilling in the lower Nikanassin sand and is testing.

Deep Production Found In New Mexico Well

Lawton Oil Company has found gas-distillate indications at its No. 2 State-Gulf, as a part of the active search for deep production being carried on in Lea County, New Mexico. On a drillstem test at 11,220-372 ft, the well showed an estimated 5,000,000 ft of gas per day in 44 min. In the second hour flow was 5 bbl through ⅝-in. choke. Gas volume at the end of the 6-hr test was 1,250,000 ft per day.

Tex Harvey Well Opens Field

Tex Harvey Employees, Inc., has completed its No. 1 Jesse Ellwood Chappell in Sterling County, Texas, opening a new oil field. The well was given a rating of 98.5 bbl of 46.5 gravity oil per day through 24/64-in. choke. Gas-oil ratio was 1600 to 1, and flow is from acidized section through perforations at 7674-84 ft in what is identified as Mississippian detrital.

Gas Pool Opener Completed

J. R. Butler and Associates have opened a new gas pool in Fort Bend County, Texas, about one mile west of the North Blueridge field. Pool opener is the No. 1 John L. Barnes, which flowed 18,000,000 cu ft of gas daily from Vicksburg sand, through perforations at 8417 to 8427 ft. Drilled to a total depth of 8460 ft, the well produces some 53.2 gravity condensate with a ratio of 33,250 to 1 and a shut-in pressure of 3201 lb.

Carter Well Flows 85 Bbl of Oil Per Hour

Flowing at the rate of 85 bbl of 43.5 gravity oil, without any water, Carter Oil Company's No. 1 Tebow in Grant County, Oklahoma, has been completed. The well, producing from the Marshall sand, was tested for five hours through 5/16-in. choke. Flow is from 5804-26 ft total depth. Gas-oil ratio was 537 to 1 with gas volume 218,000 cu ft per day.

Florida Test Gets Oil Shows

Good oil shows have been found in C. L. Smith and others' western Florida wildcat, the No. 1 Walton Land and Timber Company. The test has been drilled to 5204 ft, after finding oil shows in samples and side wall cores from 3806, 4726, to 4728, and with a questionable gas odor in a sample at 4773 ft.

Gulf Well Given Potential Flow of 5,500,000 Cu Ft

Gulf Refining Company has completed its No. 1 de Rouen in Calcasieu Parish, Louisiana, with a potential flow of 5,500,000 cu ft of gas and 59.6 bbl of condensate per day through 16/64-in. choke. Completed from the 10,924-54 level, tubing pressure in the well was 3900 lb and gravity of condensate 43.8. It is in the southeast part of parish.

Indiana Gets Largest Well

Carter Oil Company has completed what is said to be the largest oil well ever to be brought in in Indiana. It is the company's No. 1 George W. Hanshoe, Posey County, which flowed 2626 bbl of oil in 24 hr from three zones, all in the McClosky lime. The well is in the Spencer field, about seven miles southwest of Mt. Vernon.

Tensleep Formation Hit In Wyoming Oil Test

The Tensleep formation has been found productive in Carson County, Wyoming, in a C. H. Vaughan Production Company wildcat. This has been termed as "promising to be one of the most important developments of the year to date in Wyoming". The Tensleep was topped at 10,210 ft in the well, and when pipe was pulled, 64 stands came out dry but the 65th unloaded light green 45-50 gravity oil. Vaughan reamed core hole at 10,256 ft and planned to core ahead for testing.

Deep Well Brought in On Texas Gulf Coast

Texas Company has completed its deep wildcat discovery well in Brazoria County, on the Texas Gulf Coast at a total depth of 10,112 ft. The company's No. 1 Reeves et al, flowed 42.2 bbl of oil daily through a 10/64-in. choke plus a large volume of gas. Gas condensate ratio was 10,737 to 1.

Illinois Test Successful

A new wildcat well has been completed in Wayne County, Illinois, flowing 35 bbl of oil an hour. It is Illinois Mid-Continent Company's Norman Piercy No. 1, which is the only producer from the St. Louis lime within at least 50 miles. The well was completed at 3465 ft, but only the top two feet of an indicated 12 ft of productive area have been perforated, a Mid-Continent official reported.

Mexican Well May Produce 25,000 Bbl of Oil Daily

The Mexican government has reported that a tremendous well has been brought in that country's richest oil field, Golden Bell. The well may produce as much as 25,000 bbl a day, officials report, and will be named Ezequiel Ordonez, after the government geologist who first reported oil in the Poza Rica area in 1908. This is the second well drilled in the field. The drill rig first struck gas under 2400 lb pressure, and drillers went deeper to hit the oil itself.

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▸ **Lloyd Williamson,** representative from District 4, was elected chairman of the Administrative Committee, of the Conservation Committee of California Oil Producers. Williamson is president of the Lakeport Petroleum Company. The Administrative Committee is responsible for the financial and administrative affairs of the organization. Other members of this committee are **Sol Alexander, W. L. Hobro, Joseph Jensen, and Ross McCollum.**

An engineering board was also elected. **M. G. Arthur,** representative from District No. 13, and assistant chief petroleum engineer for Union Oil Company, was elected chairman. The engineering Board makes studies of oil fields to determine the proper conservation measures in the establishment of maximum efficient rates of production of crude oil. Other members elected were **George August, J. T. Carriel, R. C. Gentry, O. A. Graybeal, R. T. Hanson, Glenn V. Kersten, F. T. Lloyd, S. A. Patterson, and Carl Tutschulte.**

The new standing subcommittees will serve for one year.

▸ **D. H. Scott,** supervisor of The Texas Company's geophysical operations in the Pacific Coast division, producing department, has been transferred to the Houston, Texas, geophysical office as head of the gravity staff, it was announced by R. L. Lay, division manager of the geophysical division. Scott, a native of California, is a graduate of California Institute of Technology. Prior to being assigned to the geophysical division, he had had considerable experience in both field and office geological work. He will have charge of all phases of Texaco gravity operations.

▸ **John L. Hoard,** vice president and chief geologist of Kirkpatrick Oil Company, has resigned his position to become an independent operator. He will have his headquarters at Ardmore, Oklahoma.

▸ **Mike O. Smith, Jr.,** has been transferred from Magnolia Petroleum Company's Brownfield, Texas, producing district to the Salem district as a petroleum engineer. His headquarters will be at Salem, Illinois.

Will'am G. Sole, Jr., who has been a petroleum engineer at the Rusk producing district has been transferred to Magnolia's Alice producing district, with headquarters at Alice, Texas.

Thomas A. Flowers, Jr., has been transferred from the West Texas drilling tools department to the petroleum engineering department as a petroleum engineer and has been moved to the Chase producing district by Magnolia. He is located at Great Bend, Kansas.

Dwayne M. Coleman, petroleum engineer in Alice, has been named recipient of the Magnolia Fellowship at Texas A and M College for the scholastic year 1952 and 1953.

▸ **L. J. Richards** has been named assistant to the vice president and general manager of Hudson's Bay Oil and Gas Company, Ltd., Continental Oil Company affiliate in Canada. It was also announced that **E. L. Erickson,** regional geophysicist for Conoco at Los Angeles, will succeed Richards as chief geophysicist for Hudson. Richards, a graduate of Oklahoma A and M College, joined the geophysical department of Continental in 1937. Erickson, who joined Continental in 1937 is an engineering graduate of the University of Alberta.

▸ **Charles H. Row** has been named Southwest Texas regional geologist for Sun Oil Company. Formerly area geologist for the company at Corpus Christi, Texas, Row will maintain headquarters in Dallas. He is assuming regional duties formerly held by **Paul W. McFarland,** assistant chief geologist for the division. Row joined Sun as a geologist in 1921 and held numerous South Texas posts, becoming area geologist in 1951.

▸ **M. N. Broughton** has been promoted to division geologist, South Texas division of The Texas Company's producing department. Broughton has been a senior geologist of the Louisiana division, producing department in New Orleans. He was graduated from the University of Texas with a BA degree in 1930 and a MA degree in geology in 1931. He joined The Texas Company in 1933.

▸ **Gordon H. Gray** has returned to Condor Petroleum Company after a year's duty as a captain with U. S. Marine Corps Engineers. Upon his return, Gray has been promoted to superintendent of drilling and production for Condor, with offices in Abilene, Texas. He was formerly petroleum engineer, and field superintendent for Condor.

▸ **Dick B. Mason, Jr.,** district landman at Houston, Texas, for Stanolind Oil and Gas has been transferred to Fort Worth as division landman for the North Texas and New Mexico division.

J. D. Wheeler

W. B. Berwald

W. H. Barlow

J. D. Anderson

E. W. Shoupe

M. E. Loose

▸ **J. D. Wheeler** has been appointed division manager of The Ohio Oil Company's Houston, Texas, production division. He succeeds R. C. Gwilliam, recently deceased. Wheeler joined Ohio Oil as district petroleum engineer in the East Texas field after experience with several other oil companies as a geologist both in the United States and in foreign fields.

W. B. Berwald, assistant chief petroleum engineer, has been named assistant division manager of the Shreveport, Louisiana, production division, for Ohio Oil. **W. H. Barlow,** petroleum engineer, will become assistant chief petroleum engineer, succeeding Berwald.

J. D. Anderson, manager of the purchasing department, has been appointed assistant division manager of the Houston, Texas, production division.

E. W. Shoupe, in addition to his present capacity as purchasing agent, has been appointed manager of the purchasing department, succeeding Anderson. **M. E. Loose,** assistant to manager of the purchasing department, has been named to the newly established position of assistant manager of the purchasing department.

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International Guests at a recent meeting of the Los Angeles Nomads are: Standing, Rene Lembeye, SPAEF from French Equatorial Africa; Osvaldo Wenzel, Empresa Nacional del Petroleo from Chile; George M. A. Kayne, Trinidad Oilfield Service from Trinidad; Douglas H. Graham, Dunlap and Graham from Colombia. Seated: Ivan B. de Carvalho of Conselho Nacional do Petrolco from Brazil; W. E. Childers of Mene Grande Oil Company, Venezuela; Herbert E. Allred of Socony-Vacuum from Venezuela; I. B. Allen of Peticon, Venezuela. Not shown, C. M. Williams of Iraq Petroleum, Kirkuk.

Whing Ding prize winners are: Back row, Glenn Johnson, Baash-Ross Tool Company; Ralph Clemmons and Jack Freeman, Bethlehem Supply; Carl Krager, Richfield Oil Company; Dante Siracusa, S. R. Bowen Company. Front row, Kingsley Nicholson; Jess Andrus of Emsco Derrick and Equipment Company; Leo Cypher, Baash-Ross Tool Company. This is an annual party of the Los Angeles Nomads.

▸ **Randall K. Graber** has been named assistant geologist for Tide Water Associated Oil Company in Corpus Christi, Texas. He is a graduate of the University of Kansas. Other appointments include: **Robert M. LaPointe,** 1952 Michigan State College graduate, has been appointed assistant geologist in Tulsa, Oklahoma; **Ernest E. McDonald,** appointed assistant geologist, Midland, Texas, formerly with Rotary Engineering Company; **Robert L. Musslewhite,** named assistant geologist at Houston, University of Houston graduate, and **Homer L. Olivier,** assistant geologist at Houston, also a University of Houston graduate.

▸ **Kenneth C. Woodward,** former seismograph party chief for Carter Oil Company has set up offices as an independent oil operator in Shreveport, Louisiana.

▸ **W. B. Hoover** has been appointed geologist in charge of the Humble Oil and Refining Company's Roswell, New Mexico field office. **N. A. Sax** and **R. F. Meyer,** geologists, have been transferred from Midland, Texas, to the new office.

▸ **Blake Hawk** has been named general manager of the Texas Honduras Company. The company holds a concession from the Honduras Government covering minerals in the Central American nation, including petroleum.

▸ **Richard C. Marmaduke** has joined British American Producing Company at Dallas, Texas, as a staff geologist. He was formerly district geologist for Carter Oil Company.

▸ **Fred McMahon,** president of Pacific Petroleums, Ltd., has been named chairman of the board and chief executive officer of the company. Other officers include: **George L. McMahon,** formerly executive vice president of the company, named president; **C. H. Wright,** chairman of the board of Sunray Oil, was named director. **N. R. Whitall,** retiring chairman of the board, retains his directorship in the company.

▸ **Stewart H. Folk** was recently named geologist for the Texas Gulf Sulphur Company in Houston, Texas. He was formerly with Petroleos Mexicanos serving in Mexico.

▸ **Lawrence J. Beckmann** has been named division geologist of the Tulsa, Oklahoma, division for Union Oil Company of California. Before joining Union he was with Creole Petroleum Corporation in Venezuela for 9 years and later with Carter Oil Company.

▸ **William J. Carroll** has been appointed assistant treasurer of California Texas Oil Company, Ltd., and The Bahrein Petroleum Company, Ltd.

Carroll joined Caltex as a stenographer in 1941 and received his B.S. in 1946 from Fordham University.

▸ **William K. Brewster,** who has been a land man for Magnolia Petroleum Company in Dallas, has been transferred to Socony-Vacuum Oil Company, Inc., for duty in that company's general offices, 26 Broadway, New York City.

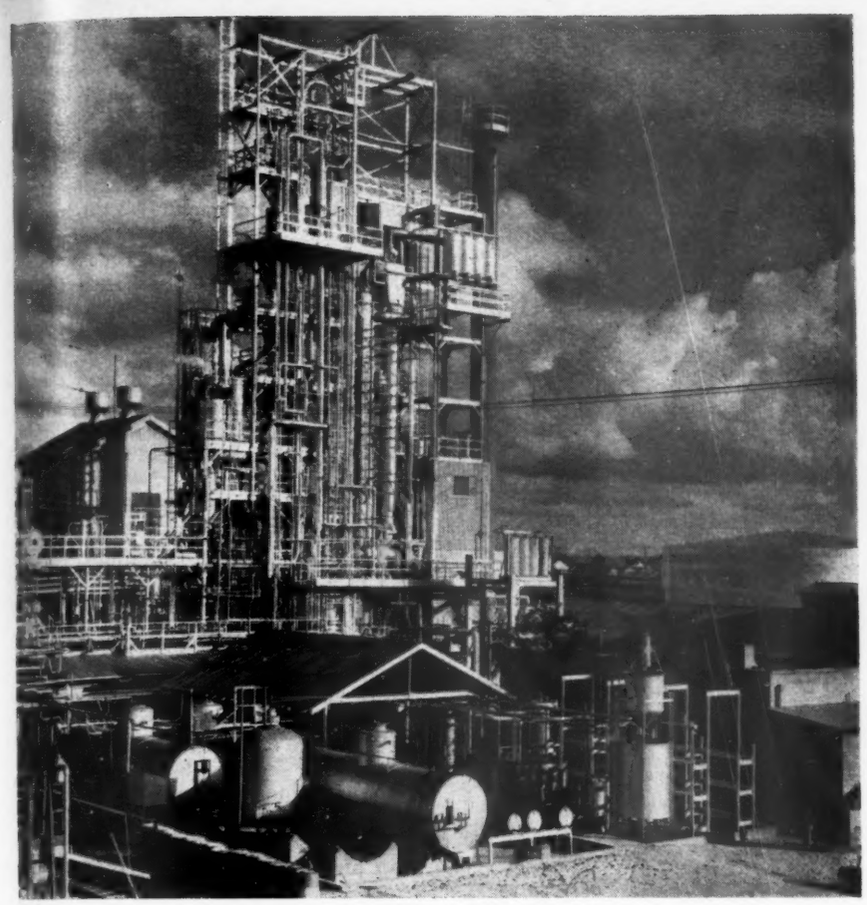
▸ **L. J. Richards** has been promoted to assistant to the vice president and general manager of Hudson's Bay Oil and Gas Company, Ltd., Continental Oil Company's affiliate in Canada, with headquarters at Calgary, Alberta, it was announced by R. C. Brown, Hudson's Bay vice president and general manager.

Simultaneously, it was announced that **E. L. Erickson,** regional geophysicist for Conoco at Los Angeles, California, will succeed Richards as chief geophysicist for Hudson's Bay Oil and Gas Company.

Richards, a graduate of Oklahoma A. and M. College, joined the geophysical department of Continental Oil Company in 1937. He became chief geophysicist for Hudson's Bay Oil and Gas Company at Calgary in 1948.

Erickson is no stranger to Alberta, being an engineering graduate of the University of Alberta. He joined Conoco in 1937 and has held progressive assignments in the company's geophysical department.

▸ **E. C. Bolger, W. C.** Norris, Manufacturer, Inc., Tulsa, Oklahoma, has been named chairman of the manufacturers' committee for 1952 and 53 of the Petroleum Equipment Suppliers Association. Other committee members include: **M. G. McCool,** American Iron and Machine Works; **Carl White, Jr.,** Franks Manufacturing; and **F. S. Denison,** Exner-Dodge, Inc.; **L. A. Little,** Lufkin Foundry and Machine; **L. L. Rector,** Rector Well Equipment; and **R. G. Hamaker,** Reed Roller Bit; **J. G. Seiler,** Tube Turns; **J. R. Mahan,** National Supply; **Lloyd Lanphere,** Ajax Iron Works; **F. C. Meritt,** Byron Jackson; **A. G. Hagludn,** Axelson Manufacturing, and **T. A. Boyd,** Baash-Ross Tool.



The synthesis plant at Baton Rouge (Louisiana) refinery.

Status of Synthetic Fuels

ARCH L. FOSTER*

DURING the apparent lull in the "storm" of discussion, report, estimate, and guestimate on the matter of synthesis of fuels, which has been occupying many minds in recent years, it may be well to look about and see how far we've advanced in this field.

A quick glance indicates definitely that we have progressed more advantageously in the technology of fuel synthesis than we have in the economics of the various processes. The different process pilot and research units gradually are developing new and improved techniques which improve yields and/or qualities of products. These improvements change the economics for the better, but have not erased the formidable margin of cost differential between synthetic fuels and those derived directly from petroleum and natural gas sources. Conclusively, all reports and all calculations to date show that synthetic fuels from whatever source — natural gas, coal, or oil shale — cannot possibly compete under existing conditions with the same fuels produced from petroleum and natural gas by non-synthetic methods.

Similarly, our present rate of crude oil production, and our present rate of addition to known and proved crude petroleum and natural gas reserves prove conclusively that not within the foreseeable future can these synthetic fuels compete in the world's markets, if the fuels are made by any methods now known or which can be prognosticated on the basis of present levels of technology.

Numerous estimates have been made by the U. S. Bureau of Mines, by the National Petroleum Council, and by independent and private agencies to show the comparative cost of production of hydrocarbon fuels by all the known methods. Obviously, the results of these estimations are determined by the assumptions made in their calculation; it is possible to so select factors that most any cost value may be evolved at the will of the calculator. Practical operations dictate that all factors that affect the cost of the product must be included in the estimate if the cost figure arrived at is to be comparable in a private enterprise economy. In all figures so far presented by governmental agencies on the cost of synthesis of fuels via the liquids-from-natural-gas, or from coal or shale oil, important omissions have been made from the final total. Generally these estimates are based on costs calculated by omitting amortization charges, or before taxes, especially income taxes. Also in at least one instance costs were estimated without including anything to pay for personnel housing, in out-of-the-way locations where costs for housing must be borne by the plants, no such housing being available in these locations.

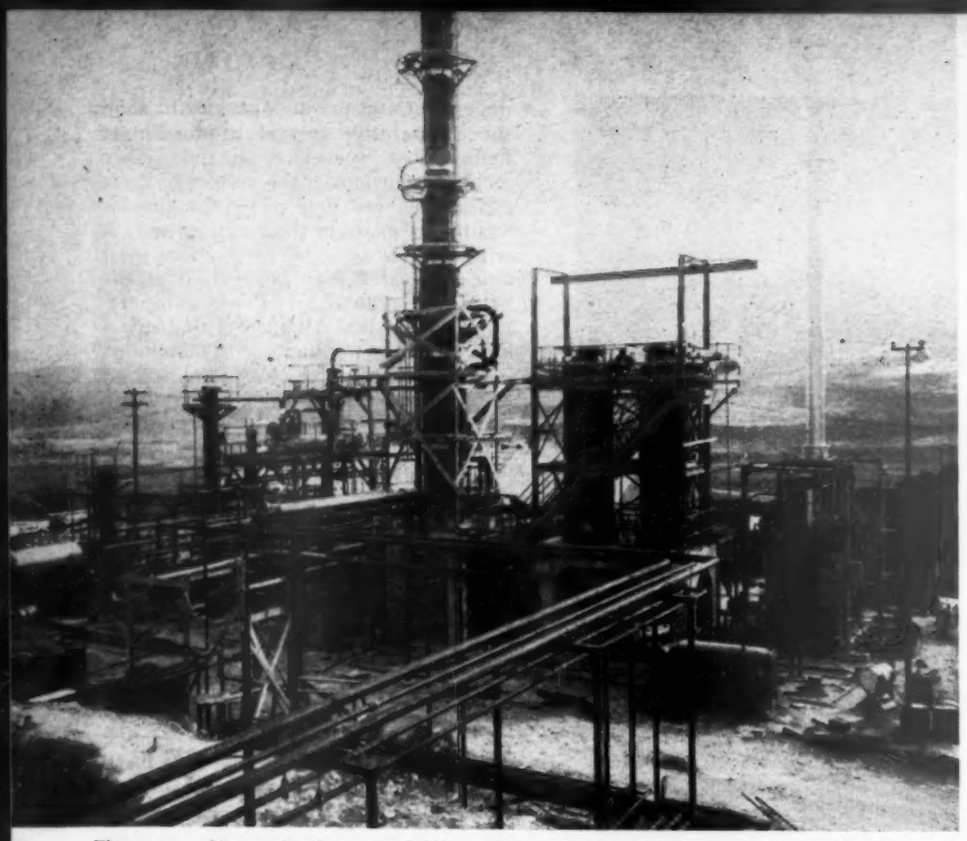
Also, the final fuel cost is made to appear too low by crediting the financial returns from byproduct chemicals at too high a figure. The flood of alcohols, aldehydes, acids, ketones, etc., formed as byproducts from the synthesis of hydrocarbons via the Hydrocol, Synthol, and similar processes would be of such volume in the event of large production of synthetic fuels that the market would be flooded, most likely, resulting in greatly lowered prices for the chemicals and consequently higher net costs for fuels. Current estimates show a margin of several cents between the costs of producing motor fuel from synthetic plants and from the conventional processes from crude petroleum.

Fuels from oil shale and from coal hydrogenation, or from coal gasification and the use of this gas as charge for the Fischer-Tropsch type of process show correspondingly greater cost differentials. The most recent authoritative estimates (Kemp, NPA, April, 1952), show that fuels from shale oil, after inclusion of cost factors of 6 per cent return on the investment including housing investment and of 50 per cent income tax (Federal) (which two items are equal to about 90 per cent of the remainder of the total costs) will cost more than 16 cents per gallon, calculated on a single shale oil plant, or 14.7 cents per gallon when 5 similar plants are operated. Corresponding investment costs range from $8370 per bbl of liquid product per day for the single plant, to $7540 for the "battery" of 5 such plants.

The margin between industry and governmental figures for the cost of fuel from the hydrogenation of coal is significant and disquieting. By what appears to be a juggling of figures showing cost of investment capital — interest charges — and by showing much lower return on investment and income tax costs, the Bureau of Mines' last estimate on a coal hydrogenation unit gives a

*Editor, Refining and Gas Processing.

EXCLUSIVE



Thermocracking unit, Bureau of Mines demonstration plant near Rifle, Colorado. From right to left: Heater, reaction chamber, coke chamber, flash-fractionator, side-cut stripper structure, stabilizer, rerun column, and gas-balance tank.

total cost of fuel of only 11 cents per gallon for a single unit. The National Petroleum Council's Committee reports a cost of 41.4 cents per gallon for a single plant, or 43.5 cents for fuel made by a group of 8 similar units. The NPC's figures show that the 6 per cent return on investment and the Federal income tax items amounted to more than the initial costs before these items are included; all these figures are calculated on the basis of customary business methods for private capital operations. The investment returns and income tax items in the Federal estimate are only one-third of the same items in the industry estimates.

Current and immediate past history of coal hydrogenation and shale oil processing shows a decidedly unfavorable result of these operations. Technically, coal hydrogenation in Germany was "profitable" in recent years only because war's demands and a war-totalitarian economy recked not of the money cost, the economics of the operation, but synthesized the products at any price, in order to obtain them. Costs even under Nazi methods could not compete with petroleum products' costs. Most recently the oil shale operations in Australia have been discontinued, and the technical and operating personnel have been scattered, a development traceable directly to unprofitable ratio between production costs and market prices. The most recent estimate from an authoritative Australian source* states that important reduction in mining costs for Australian operations must be made, also better protection by embargo, tariff, or subsidy must be given before operations there can be economical. This authority emphasizes the stated fact that shale oil there, showing 100 gal or higher yield per ton of raw shale, is an important potential source of raw materials for petrochemicals which may be considered carefully by leaders in "The 5th Continent."

*Article by Nottes, soon to be published.

Technological Advances

Technical-wise, the synthesis of fuels by these various processes presents a more attractive picture. Omitting the economics of the situation in coal hydrogenation, mentioned above briefly, the technology of this process is progessing at what may be considered a rapid rate for Bureau of Mines operations. Estimates by NPC show that from 12,960 tons of bituminous coal a total liquid yield of 25,880 bbl may be had as a day's output (calendar) from a single unit with 1120 bbl of various chemicals; Bureau estimates show 25,630 bbl of liquid hydrocarbons, and 4370 bbl of chemicals for 30,000 bbl per day total. The NPC figures are based on a 90 per cent operation factor while the Bureau assumed continuous operation every day in the year. The process for coal hydrogenation, however, is still considered to be far from practicable, even technically speaking.

In oil shale and shale oil more progress has been made. Especially attractive, comparatively speaking, is the development in oil shale mining achieved by the Bureau organization in Colorado, where per-ton costs of 50-55 cents are considered by industry as demonstrated. Retorting the shale has progressed with the study of operations on especially two retort types, the Union Oil upflow and the gas combustion retort. Various refining research organizations are studying the huge problem of the best methods for refining shale oil. Hydrogenation, or vis-breaking followed by hydrogenation, catalytic cracking, etc., are some of the treatments mentioned by Storch (ACS, 1951). A coking operation, hydrogenation of the heavier fraction and catalytic cracking of the hydrogenate, has been carried out in a pilot plant by the Bureau, yielding nearly 100 volume per cent of jet and diesel fuels based on the hydrogenation charge. A great deal of fundamental work has been and is being done at Rifle, Colorado, in the experimental refinery there.

While both Federal and private interests are studying the synthesis of liquid hydrocarbons from natural gas, as well as from coal, lignite, etc., probably the most outstanding accomplishments are those at the Brownsville, Texas, plant of Carthage Hydrocol. One of the important problems solved is the use of the Collins countercurrent heat exchanger called a switching exchanger, wherein air and nitrogen are switched in flow in one division of the exchanger and oxygen is allowed to flow in a separate pass continuously, which yields high purity oxygen while eliminating water and carbon dioxide deposits therein, a problem which it is understood plagued the Germans and others. Storch reports that, while the externally cooled granular catalyst fixed-bed Ruhrchemie process operates in "the steady state" for 150 to 200 days continuously, and the oil circulation process for 100 to 200 days as against only 20 days for the fluid bed process, as used at Brownsville presumably, the high space-time yield in fluid operations is so much greater that it more than offsets the short on-stream time disadvantage. Some of the further improvements to be striven for are a fluidized-iron catalyst which will not be oxidized appreciably during on-stream periods; a more active and mechanically stable catalyst for the oil circulation process to further reduce methane and ethane production.

Isomerization of olefins produced in synthesis, to transfer the double bond nearer the middle of the molecule, is being used at Brownsville, report says, to improve the octane rating of the gasoline by as much as 20 units. Using a cracking catalyst under mild conditions, the large proportion of straight chain olefins is isomerized to higher octane ratings, operating in the vapor phase. Oxygenated compounds at the same time are converted to water and hydrocarbons under these conditions, it is reported (Gunness, ACS, 1951).

A few months ago announcement was made of contracts for a coal-to-gasoline (and other hydrocarbons) plant using the Synthol process on coal in South Africa, which unit is presumably now under construction. At that time it was stated that oxygenated byproducts would be reconverted to hydrocarbons to augment the yield of fuels. Whether or not some process similar to the above mentioned isomerization routine with a cracking catalyst will be employed for this deoxygenation operation has not been made public. * * *

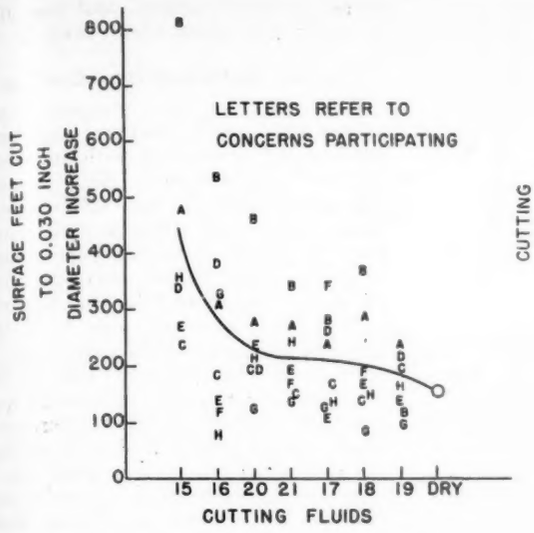


FIG. 1. Plant evaluation of cutting fluids.

Section of the reported results of one of the first cooperative lathe turning tests. Eight companies participated and tests were conducted using seven types of cutting fluids that were previously agreed upon by the members of Section 1 and Section 2 of Technical Committee K. The test work was carried on in the shops of each of the eight participating concerns, each of whom used their own lathes but all used the same type tool holder, especially designed for this test work. The test logs were identical, of AISI 1020 steel; 4½ in. diameter. Cutting tool blanks were all obtained from the same billet and all tools and angles were identical. The chart identifies the participant by letter, situated on an ordinate, identifying each cutting fluid, at a height corresponding to the performance record of surface feet of metal cut to where the log diameter had increased to 0.030 inch over the starting measurements.

REFERENCE: Progress Report No. 2, ASTM, Technical Committee K, Cutting Fluids, April 25, 1951.

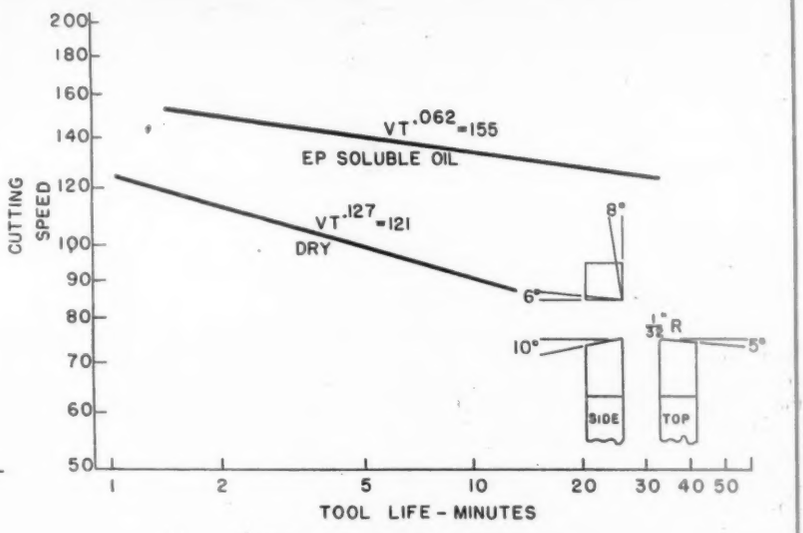


FIG. 2. Cutting fluid performance.

Tool life test data curves, showing a pronounced increase in tool life between wet and dry cuts under identical cutting conditions. At higher speeds, the cutting fluid depends on its coolant capacity more than its friction reducing properties due to the throw-off of fluid from the cutting zone in a conventional flooding application. The data also show that the use of a cutting oil is not too effective at the higher cutting speeds. Most of the Sinclair work to date has been concerned with development of test procedure and repeatibility of results. The tests were run on an American "Pacemaker" lathe, AISI test log of 4150 steel, Brinell hardness 225 BHN, High speed steel tools of the DBL-2 type (Allegheny Ludlum Steel Company) ground as indicated to 0—8—10—6—5—0—1/32-in. Depth of cut 0.100 in., feed 0.01 in. per revolution. Cutting fluid EP soluble oil 5 per cent emulsion in water. Tool setting, a special tool holder was used giving a true back rake of 4 deg.

Cutting Fluids for Machine Tools

C. M. LARSON*

WITH a very substantial expansion of machine tool production in the years 1952 and 1953, and the rapid increase in defense plants using these new machine tools, the operators of such plants will need assistance from the lubrication engineers in the proper understanding and application of cutting fluids. Also, plant management is forced to seek these new machine tools and the proper cutting fluid selection to offset higher wages and material costs.

*Chief consulting engineer, Sinclair Refining Company, New York, New York.

The subject of metal cutting has been under study for almost a century, but recently the level of cut-and-try shop procedure, of a decade ago, has been undergoing a transition from an art to a science. Scientific research in metal cutting and its ramifications, is leading to advances in machining practice and improvements in cutting fluids. To date, field service trials, with closely controlled tests run in the cutting-fluid user's plant, under actual production conditions are the only true comparison of cutting fluids.

EXCLUSIVE

A cutting fluid may be defined as any liquid substance applied to a cutting tool to assist in the cutting operation.[1] M. E. Merchant[2] and M. C. Shaw and his co-workers[3] have reported that coolants (cutting fluids) reduce the chip-tool interface temperature by direct transfer of heat and by reducing the friction between chip and tool. Therefore, every successful cutting fluid must act both as a coolant to remove heat from the cutting tool and work, and

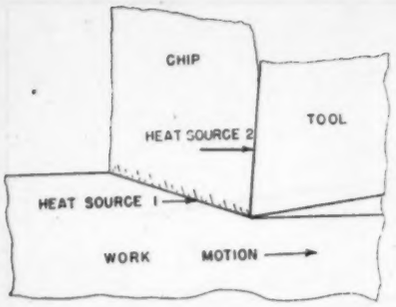


FIG. 3. Sources of heat in metal cutting.

The shear zone[1] and the tool-chip interface[2] are the two distinct regions of heat generation during metal cutting operations that produce a Type 2 chip. The shearing of the metal, along the first zone, causes a temperature rise of several hundred degrees in the bulk of the chip as it is severely deformed. At the chip bulk temperatures involved, the traverse time of the chip, is long as compared with the time required for heat diffusion of the dislocations. It is believed that a strain-hardened chip will exhibit its influence at the tool-chip interface. The steep temperature gradient in the chip, at the interface, is thought to have on effect on the variation of interface friction with change of temperature. The cutting speed-cutting temperature relationship at various feeds forms a family of approximately parallel straight lines on logarithmic coordinates. At a given speed, the cutting temperatures on the interface increase with an increase in feed. This effect becomes smaller as the feed is further increased.

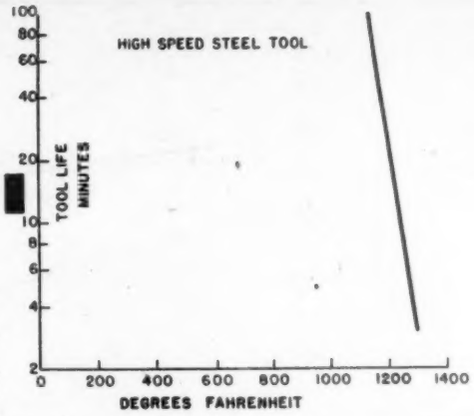


FIG. 4. Tool life vs cutting temperature.

The relationship between tool life and the temperature of the cutting tool depends mainly on the tool material and work material. It is evident that a very small change in tool temperature will produce a large change in tool life. It has been calculated that a reduction of 77 F in tool temperature raises tool life 150 per cent.

REFERENCE: *Fundamental Aspects of Metal Cutting & Cutting Fluid Action*, by Hans Ernst, Annals of the New York Academy of Sciences, Vol. 53, June 27, 1951—p 936-961.

as a lubricant to reduce the friction between the flowing chip and the cutting tool. In practice a cutting fluid has to perform many different functions, depending upon the type of machining or metal removal operation. In such metal cutting it is desirable to have high cutting speeds, long tool life, good chip removal, low cutting temperatures and low power consumption, in addition to the prevention of rusting and corrosion of the finished work. The use of the proper cutting fluid properly applied to the tool point or cutting surface is essential to the satisfactory performance of machine tools and to the attainment of correct work piece size and finish at maximum production rates.

Heat Removal As a Coolant

The cooling or heat removal ability of a cutting fluid directly affects the life of the cutting tool. A small change in tool temperature will produce a large difference in tool life. It has been calculated that a reduction of 77 F in tool temperature raises tool life 150 per cent.

The development of high speed steels and increased machining speeds have made temperature control necessary. Changes in cutting edge angles caused by wear, begin as soon as the cutting operation starts. The principle objectives of metal cutting are the highest cutting speeds for the desired tool life, good quality of machined surfaces, low force of power requirement, well broken up chips, consistent dimensional accuracy and maximum metal removal per tool grind. The major factors involved are the metal being cut, the cutting tool, the cutting fluid and its flow, the process or type of machine, and the size and shape of cut.

Among the necessary properties of cutting fluids are high specific heat, high heat conductivity, good wetting and lubrication properties, including extreme pressure qualities, and rust and corrosion prevention where needed.

Thermal Conductivity—Cooling

It is important that the cutting fluid have a high specific heat and high heat conductivity, consistent with its other required characteristics. Aqueous cutting fluids have a heat-transfer coefficient significantly different from water for a given set of machine operations. In general, heat-transfer improves with increase in water dilution. One aqueous cutting fluid, however, may be a far better heat-transfer fluid than another, even at the same dilution. Part of the difference is due to the oil content, and part to the viscosity at 100 F differences. This is more pronounced with cutting oils employing fats, and/or additives.

In order to get the best results, the flow of the coolant or cutting fluid should be ample. It should flow at high velocity and should be directed at the cutting edge of the tool, being sure that the chip does not interfere with the flow of the cutting fluid. In addition, the tank capacity should be great enough to keep the temperature of the cutting fluid itself from increasing to the point where maximum benefits are no longer obtained.

Wetting Properties

Cutting fluids must adhere to the workpiece and have good wetting properties. Frequently the two properties go together, but some coolants run off certain metals without spreading over the surface, much like mercury runs off steel. The good wetting properties are associated with good spreading characteristics, since the coolant or cutting fluid must flow quickly over, and completely cover the tool tip and work piece. It must stay there long enough to remove

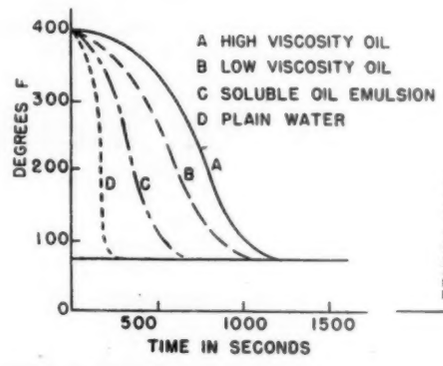


FIG. 5. Cooling rate of metal block.

In order to show the relative cooling effect of various fluids which are used for metal cutting, a cube of metal was prepared by embedding a thermocouple at its center, heating the block to 400 F and plunging it into each of the fluids. The relative cooling rate for each fluid is shown by the chart.

REFERENCE: Extemporaneous section of paper by Thomas Badger ASME, Atlantic City, Nov. 28, 1951.

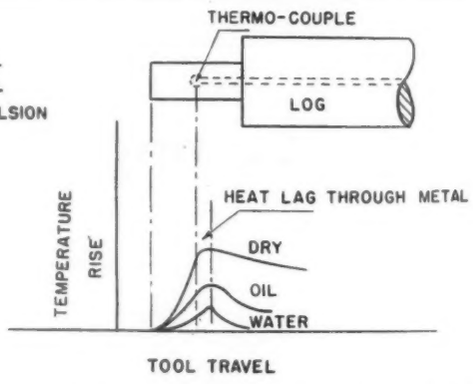


FIG. 6. Heat absorption by cutting fluid.

This reproduction represents the cooling effect of various fluids used for metal cutting, together with a dry condition. A thermocouple was placed at the center of a metal work-piece and three cuts were made; one dry, one with oil, and another with water. The temperature rise was greatest for the dry condition and least for water. Metal retained greatest amount of heat with the dry cut; least when water was used.

REFERENCE: Extemporaneous section of paper by Thomas Badger ASME, Atlantic City, November 28, 1951.

1. ASTM Committee D-2, Tech. Com. K, Sub-Com. K-III on Definitions, Functions, Types, and Designations of Cutting Fluids, O. W. Boston, Chairman.
2. "Fundamentals of Cutting Fluid Action," by M. E. Merchant, Lubrication Engineering, vol. 4, 1950.
3. "The Effect of the Cutting Fluid Upon Chip-Tool Interface Temperature," by M. C. Shaw, J. D. Pigott and L. P. Richardson, Trans. ASME, vol. 73, 1951.

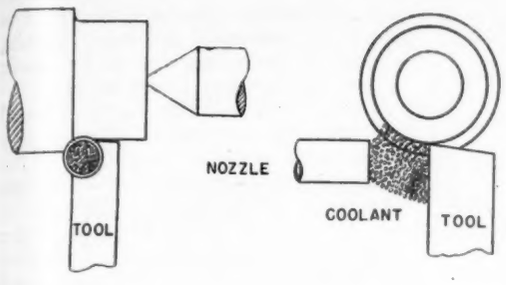


FIG. 7. Applications on lathe-type operations.

On horizontal-type turning and boring, the cutting fluid should be directed by piping, onto the cutting tool so as to submerge the portion of the tool that is producing the chip. This plan and end-elevation view indicates a good method for straight turning. Inverted tools, drilling and reaming, on horizontal machines should have the flow to the tool arranged so that the cutting fluid is under enough pressure to force it to submerge the cutting edge and the chip.

REFERENCE: *The Application of Cutting Fluids to Machining Operations*, by R. B. Niebusch and E. H. Strieder, Mechanical Engineering, March, 1951.

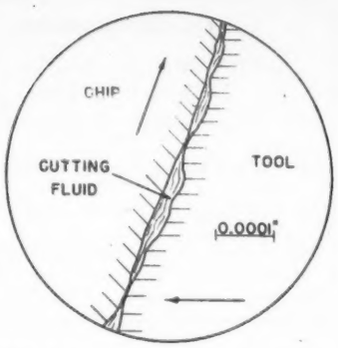


FIG. 8. Minute capillaries between chip and tool draw in cutting fluid.

Minute capillaries exist at the chip-tool interface because the surface of the cutting tool can never be smooth to a microscopic scale. This schematic, magnified, view of a tiny section of the chip-tool interface shows how the cutting fluid enters and remains as the chip slides across the surface of the tool. The actual local flash temperature on this area may reach a value high enough to vaporize the cutting fluid that must resist the bonding or welding of the metal chip to the tool.

REFERENCE: *Fundamentals of Cutting Fluid Action*, by M. Eugene Merchant, Lubrication Engineering, August, 1950.

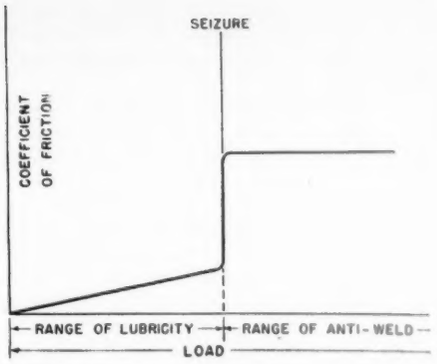


FIG. 9. Comparison of bearing and cutting tool lubrication.

In the boundary lubrication of surfaces where no continuous fluid film is present and where oil-wet surfaces are rubbing over each other, the lubricity of the oil prevents actual metallic contact. As the load on the surfaces increase, the coefficient of friction rises until the pressure on the bearing is so great that the boundary film is wiped away. The consequent metal-to-metal contact results in seizure. This seizure of steel components can be prevented only by the addition of anti-welding ingredients to the bearing oil. Welding is prevented although the metallic surfaces rub over each other with a greatly increased coefficient of friction. In the lubrication of cutting tools, both the lubricity and anti-weld ranges must always be considered. For example, in the boundary area of the tool, where the tool intermittently deflects against the work, lubricity agents are required in order to minimize friction at that point. In the lip area, where extreme pressures and temperatures are encountered, anti-welding ingredients are necessary to prevent periodic seizure and welding.

heat as it flows away. The property of adherence is more important in the case of straight cutting oils because of their lower specific heat. It is also true with extreme pressure additive type fluids. All grades of cutting fluids must have their quota of wetting and adherence properties.

Lubrication

The ability of the cutting fluid to reduce the friction between the chip and tool is a very important function. Thus the fluid is so compounded that it will penetrate to the cutting edge of the tool and chip contacts needing the benefit of lubrication. Adequate lubrication at the cutting points avoids chatter of the tool so that the tool cuts smoothly and leaves a better surface finish because the edge of the tool is prevented from building up and changing its shape. Thus tool forces and power consumption are lowered. Straight cutting oils possess the property of lubrication to a higher degree than do diluted soluble oils. Some lubricating properties are necessary in both classes of oil, but can be sacrificed to provide better cooling properties, except where tool wear must be reduced to a minimum or surface finish of the metal must be perfect.

METAL CUTTING FLUIDS

	COMPOSITION MAKE-UP				
	S.U.V. at 100 F	Mineral oil %	Lard oil % min.	Added sulfur % min.	Additional %
INACTIVE CUTTING FLUIDS					
Mineral oils	32–110	100			
Mineral oil and lard oil	110–220	75–95	5–25		
Mineral oil, lard oil and sulfur	35–320	64–99	1.5–33	0.5–3.0	
Sulfurized bases (at 210 F)	100–400	0–50	44–88	5.0–10.5	
ACTIVE CUTTING FLUIDS					
Mineral oil and sulfur	115–125	99		1.0	
Mineral oil, lard oil and sulfur	110–260	80–90	3–15	1.0–4.25	
Mineral oil, lard oil sulfur and chlorine	50–70	78–90	4.5–14	1.5–3.0	Chlorinated
Mineral oil, sulfur, chlorine	100–120	98		2.0	Chlorine

FIG. 10. Metal cutting fluids.

In classifying cutting fluids, a sharp distinction must be made between cutting oils and soluble oils. The cutting oils are blends using mineral oil, with or without fatty oil, with or without sulfur and/or chlorine. The severity of the operation indicates the type and amount of compound and additive to be used. Soluble oils are never used in the form they are received but are mixed with water at the user's plant to the strength necessary for the job. A wide variety of products are available. The latest additions being EP soluble oils, incorporating added lubricity and transparent cutting oils, better visability and flexibility.

Chip Removal

In addition to cooling and lubricating the chip, to make it break more easily, the cutting fluid serves to carry the chip away, thus preventing accumulation of chips at the cutting point. Ready separation of the chips and microscopic particles from the cutting fluid, either by physical or mechanical means is also essential to tool life and surface finish requirements.

Types of Cutting Fluids

The many types of cutting fluids in use are built around various combinations of cooling, lubrication, film-forming, anti-rusting and anti-corrosion properties desired for the different metals, operations production rate, surface finish and tool life. There are two general types of cutting fluids: Cutting oils (mineral oils and compounded) and soluble (or emulsifiable) oils. The compounded cutting oils offer a greater variety of blended components, to fit the numerous requirements of the machining operating; and they have applications in a wider field of usage.

Cutting Oils

Cutting oils that represent one of the two general classifications of cutting fluids, may be subdivided broadly into six groups, each containing mineral oil in substantial amounts.

a. Lard, sulfur, and chlorine (ac-

tive) compounds. For the most severe operations on the hardest cutting steels and for thread grinding.

b. Lard oil and sulfur (active) compounds. For severe operations and on harder cutting steels on various operations.
c. Lard oil and sulfur (passive or inactive) compounds. For all cutting operations on the easier cutting steels and for less severe operations on harder cutting steels.
d. Lard oil compounds (mineral lard oils). Principally for metals other than steel.
e. Mineral oil, sulfur, and chlorine (active) compound. For use on medium and low carbon steel when speed of production and/or accuracy of finish are not an important consideration.
f. Straight mineral oil (petroleum oil without compound). Used for machining non-ferrous type metals. Also, used as a blending oil to adjust active or passive compounds to a composition suited for specific requirements of less severity than those for which the purchased compound oil is capable.

Cutting Fluid Ingredients

Mineral Oil. The mineral oil used in cutting fluids is selected for suitable characteristics when used in various operations. In all cases it must be of high enough flash point to preclude any possible evaporation or fire hazard. It must be resistant to oxidation when exposed to air at high temperatures, so that it will not thicken in use. It must have low viscosity for highspeed operations so that the fluid can reach the cutting edge of the tool quickly, and get away freely to dissipate the heat. On the other hand, on slow-speed operations it must be adhesive in character to stick to the work.

Lard Oil. Lard oil, which was the original cutting oil, is still useful in many cutting operations as it enables the fluid to "wet" the metal more quickly and completely, and makes a somewhat stronger lubricating film than straight mineral oil. Lard oil is compounded in varying proportions with mineral oils of different viscosity.

METAL CUTTING FLUIDS

CUTTING OILS	SOLUBLE OILS
MINERAL OIL BLENDS	
Lard, sulphur chlorine (active)—sulfonated type	
Lard, oil and sulphur (active)—alcoholic soap type	
Lard, oil and sulphur (passive)—soluble paste	
Lard, oil (mineral lard oils)—grade 1	
Sulphur and chlorine (active)—grade 2	
Straight petroleum oil	

FIG. 11. Metal cutting fluids (oils).

The general physical characteristics of representative metal cutting oils are shown for comparison. All types are indicated, from straight mineral oils used for blending, thru mineral lard oils to sulfurized bases, which must be cut back with comparatively light mineral oils for use. The transparent type oils are also shown. This product is finding favor on certain operations where a constant view of the work is required.

Sulfur. Sulfur has become a valuable additive, particularly in the machining of steel because it prevents the pick-up or welding of very small particles of the work to the tool. Welding quickly destroys the cutting edge and necessitates regrinding. Sulfur fortifies the lubricating film in such a way that this pickup is prevented. Sulfur may be incorporated into lard and mineral oils in varying porportions at varying temperatures. The temperature at which it is added determines the "activity" of the cutting oil. Accordingly, a copper strip will be discolored when sufficient temperature rise occurs in such oil. Oils containing sulfur give better protection against welding under heavy loads such as broaching and threading, and are usually used on those operations.

On the other land, sulfur when added to the lard and mineral oils at a certain temperature will be passive or inactive and will not corrode the copper strip. This is a desirable feature when it is necessary to protect the bearings of the machine tool. Similarly, in some cases it is desirable to protect the work. For this reason, the passive sulfur is generally preferred for many cutting operations including that of automatic screw machines and turret lathes.

Chlorine. In addition to the mineral oil, lard oil, and sulfur, chlorine is a useful additive in the machining of the harder steels, particularly at low speeds and under heavy pressure. Chlorine as an additive was developed through the experience of many operators when they were unable to make cutting tools stand up. The addition of a little carbon-tetrachloride was found very effective but, at the same time, proved to be a health hazard for the operator and, in addition, evaporated quickly. Moreover, it is very expensive. In the later development of cutting fluids it has become possible to combine chlorine in stable form with other materials and to use it for metal cutting.

Mineral lard blends without chlorine are used principally on non-ferrous (other than iron and steel) metals because they are not likely to weld.

The body of a cutting oil will vary from a very light-bodied oil for high speed, light duty cutting, to very heavy-body products for low-speed, heavy duty jobs.

Cutting oils should have the least possible viscosity to assist centrifuging. It is easier to separate chips in a centrifuge from a low viscosity cutting oil than from a viscous one. A lower viscosity oil also has a higher thermal conductivity, and less power is required to drive the circulation pump. As is the case with lubricating oils, cutting oils should also be chemically stable and resist any tendency to oxidize. An oil that breaks down in this way will cause deposits on machine slides and other parts.

Soluble oils are in a different classification as they are mixed with water and the emulsions thus formed are the cutting fluids. They are used principally where the primary requirements calls for a coolant, and where little lubrication is needed.

Each type and grade of cutting oil has definite properties that fit it specifically and in preference to others, for particu-

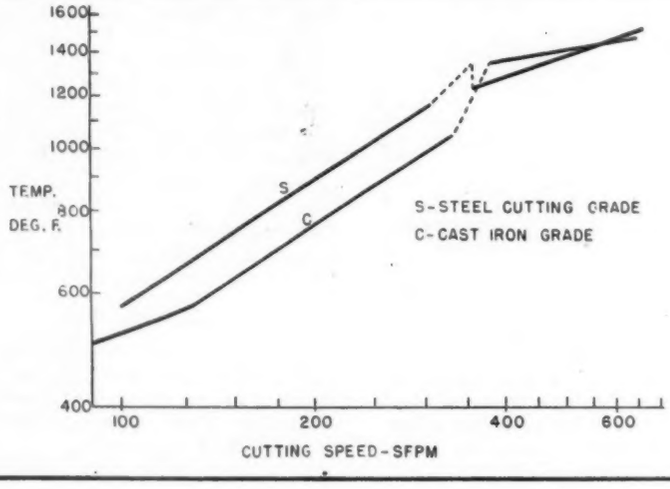
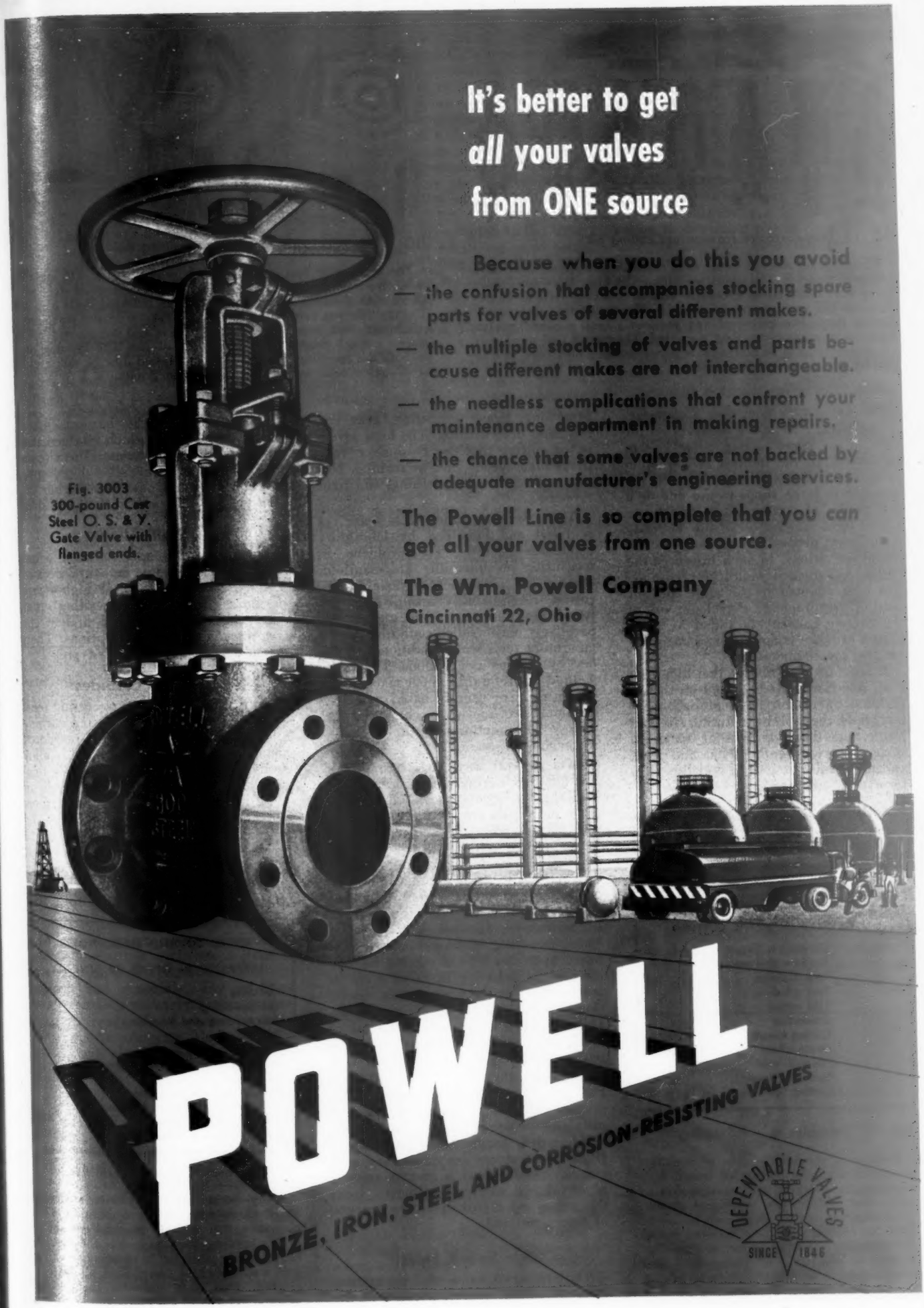


FIG. 12. Cutting speed vs cutting temperature.

Summarization of several duplicate tests, all in close agreement, show the cutting speed-cutting temperature relationship using cemented carbide tools and annealed Nodular iron. The dash line indicates the abrupt temperature rise as welding starts and builds up on the tool. As the build-up portion breaks away, the temperature suddenly decreases. This effect is more pronounced with other tools and softer metals.

REFERENCE: *Tool Forces and Tool-Chip Adhesion in the Machining of Nodular Cast Iron,* by K. J. Trigger, L. B. Zlystra & B. T. Chao ASTM paper No. 51-A39, Nov. 1951.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all your valves
from ONE source
Because when you do this you avoid
— the confusion that accompanies stocking spare parts for valves of several different makes.
— the multiple stocking of valves and parts because different makes are not interchangeable.
— the needless complications that confront your maintenance department in making repairs.
— the chance that some valves are not backed by adequate manufacturer's engineering services.
The Powell Line is so complete that you can get all your valves from one source.
The Wm. Powell Company
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Fig. 3003 300-pound Cast Steel O. S. & Y. Gate Valve with flanged ends.
POWELL
BRONZE, IRON, STEEL AND CORROSION-RESISTING VALVES
DEPENDABLE VALVES
SINCE 1846

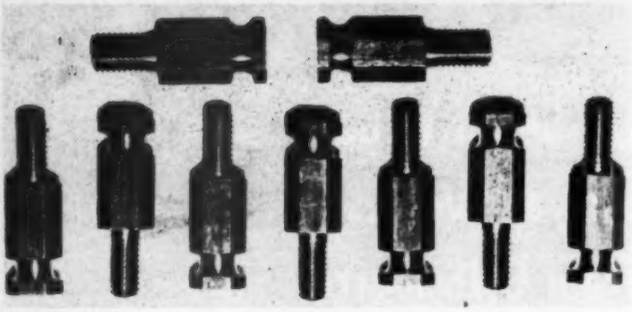

FIG. 13. Non-corrosive transparent cutting oil.

These Spring Anchor Studs were made of stressproof steel on a 5-spindle Model B, Davenport machine using high speed steel tools. There were 7 operations necessary with an indexing cycle of 11 sec. The tool life was increased 8 times by the use of this transparent cutting fluid. The knee tool had previously been ground once an hour but now completes 8 hr per grind. The cut-off tool previously ground every 10 to 30 min, now requires grinding only once in 8 hr against previously hourly grinding.

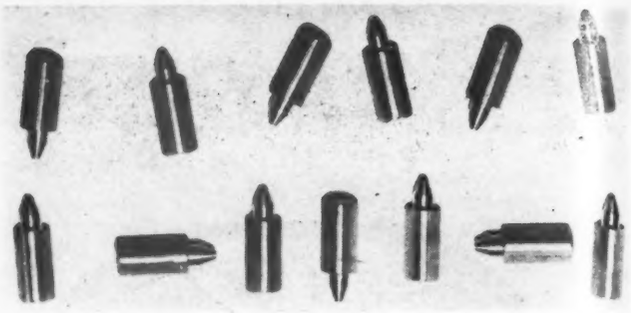

FIG. 14. Non-corrosive transparent cutting fluid.

The carburetor float needles shown were made of 416 stainless steel on a 5-spindle Davenport machine using high-speed steel tools. There were 6 operations necessary with an indexing cycle of 5 sec. The tool life was considered remarkable for the reason that several cutting oils had been tried without success and the present oil replaced a much more expensive mixture of oils. The forming tools on both the roughing and finishing cuts lasted 3 hr 15 min and all of the other tools went full 8 hr between grinds.

lar operations. Seldom does a manufacturing plant purchase a separate oil for each of the many cutting operations to be served. In the interest of minimum inventory and flexibility it is often the practice in large shops to use one or a few grades of cutting oil, to which are added light mineral oil of low viscosity in different proportions to meet the different operations. In such instances the cutting oil stocked would be of the active type adapted to the more difficult cutting requirement. Petroleum oil of the proper viscosity is added to make grades of lesser compound and adequate for less severe operations.

It must be remembered that a cutting fluid selection must be based on the individual operation, the material being machined, the tool, its material, size and shape, and the conditions of operation such as speed, depth of cut and feed, and the results desired in tool life, chip formation, and finish.

Selection of Proper Cutting Fluids

The most severe cutting operations are those that are done at relatively low speeds, and under heavy and somewhat intermittent loading. Examples are broaching, heavy threading, gear cutting, and deep drilling. The least severe is the cutting that can be done at relatively high speeds such as turning, boring, milling, shallow drilling, and light threading.

VARIABLES IN METAL CUTTING

Material to be cut
Machine tool used
Tool material
Tool grinding
Tool setting
Operation
Cutting speed
Depth of cut
Feed
Finish required
Cutting fluid used

FIG. 15. Variables in metal cutting.

Because of the vast number of variables associated with the cutting of metal, it is necessary to consider their relationship to each other before any intelligent recommendation for cutting fluids can be given. Even the cutting fluid itself becomes one of the variables but it is subject to other important details, fixed or changeable; and some condition or quality, characteristic of the material, tool, or operation.

The ease with which metals are cut is rated and classified by laboratory machinability tests. The problems in measuring machinability are manifold. Because of the numerous variables involved, machinability ratings must be based upon shop operations under comparatively uncontrolled conditions, or on laboratory tests with conditions simplified by various assumptions. The latter method is preferable. Such machinability ratings are usually based upon determination of tool wear, chip behavior, energy consumption, or rate of metal removal.

In a general way, low strength and low ductility during cutting seem to be desirable for good machinability. As these properties are mutually contradictory for most metals, the desired balance between them would be expected to vary for different machining operations. Consequently, it seems likely that steels that are good for certain types of cutting may be unsatisfactory for other machining operations. Caution should be exercised in using machinability ratings based upon one type of cutting for predicting the behavior in other types of machining. For the same reason, discretion should be used in accepting machinability ratings based upon physical or mechanical properties rather than upon performance in simulative tests.

There are three basic types of material used in cutting tools, and the important difference in the cutting tool metals is the temperature at which they will lose their hardness and cease to cut. High temperatures are caused by high cutting speeds where a greater amount of metal per minute is removed from the work, and a corresponding amount of heat generated.

High Speed Steel

The first steels to be used for cutting tools were high carbon because at the time, these were the hardest. Later, when special alloys which retained their hardness at higher temperatures, came into use, they were called high speed steel because they permitted higher cutting speeds. They are still widely used.

Cobalt Alloys

Some 30 years ago, the first cobalt alloy (Stellite) came into use because it retained its hardness at higher temperatures than the prevailing high speed steel and permitted higher cutting speeds on many operations. There are now other alloys of this type.

Cemented Carbides

Within the last 15 years cutting tools have been made, from tungsten carbide alloyed with cobalt, by the powdered metal and sintering process. This alloy retains its hardness at still higher temperature. These carbides are made in small blocks to various sizes for various cutting tools. They are cemented — or brazed — under high temperatures, to recesses cut in the steel shanks that carry them and the cutting is actually done by the small sintered carbide insert. With these various cutting tool

METAL CUTTING OPERATIONS

ARRANGED IN ORDER OF SEVERITY

Broaching
Pipe threading
Plain tapping and threading
Gear cutting
Deep Drilling
Multiple spindle automatic screw machine milling, boring, turret lathe operations
Forming, drilling, threading operations,
High speed light feed operations on
Automatic screw machines
Sawing, grinding, thread grinding

FIG. 16. Metal Cutting Operations.

Many operations are very severe and some are comparatively simple and mild. Chip clearance, tool contact area, and the ability of the cutting fluid to reach the cutting edges of the tool for lubricating, cooling, and washing chips away, must all be considered. This slide indicates the general order of severity of machine tool operations.

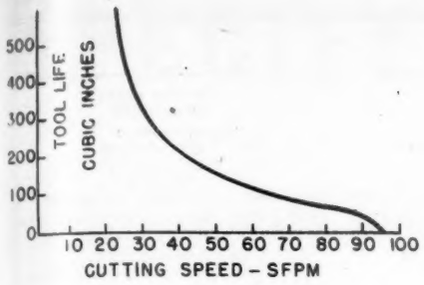

FIG. 17. Tool life vs cutting speed

When establishing the test procedure for selecting cutting tools, determination of a cutting speed is probably of first importance. The urge for a fast test often results in selecting a cutting speed that is too high to give reproducible results. Time and material may be wasted if too low speed is used. These errors can be avoided by selecting the cutting speed from a tool-life vs speed curve developed by using the work material, tool material, tool design, and test equipment that are to be used in the actual test. Note that this curve, Fig. 17, is parabolic in form to a point about 85 surface feet per minute and as the speed increases beyond this point the curve abruptly changes and drops rapidly to a point representing instantaneous tool failure. Tests run at speeds lower than where the curve changes direction will be reproducible; those run at higher speeds will be erratic. A safe rule would be to select a speed of 85 per cent of that determined from the point of inflection of the trial curve.

REFERENCE: Paper by Thomas Badger, ASME, Atlantic City, Nov. 28, 1951.

materials different types of cutting fluid are often needed.

As an aid in selection of suitable cutting fluids the accompanying recommendation chart was drawn up.

In this cutting fluid chart, the operations have been arranged in the order of severity, and the steels divided into easier cutting and harder cutting groups. It will be noted, in the cutting fluid chart, that more than one cutting fluid is recommended under each operation for both the easier and harder cutting metals. The chart is based on manufacturers' practice, which is the only satisfactory basis for recommendations.

No one manufacturer uses all of these cutting fluids, but each has a definite advantage in some combination of operations and materials. The operator usually prefers to carry fewer grades, using a stronger fluid where a weaker one would be adequate. He can reduce the strength of a cutting fluid by diluting it with mineral oil of the correct viscosity. In emergency, he can even use a fluid that is not strong enough for high efficiency, by reducing the cutting speed or feed.

In offering the cutting fluid for the user's requirement, it is necessary to know whether he is basing his selection on the most effective fluid for the hardest operation, of how far he wants to go in accommodating it to other operations. If the hardest operation is a large production job he will probably want the most effective cutting fluid he can get. If, on the other hand, the hardest operation is infrequent, he may logically prefer a fluid of lower compounding. In general, where most of the machining operations are performed, at least three cutting fluids will be needed, as follows:

1. An oil compounded with lard oil and active sulfur, with or without chlorine, as requirements may indicate.
2. An oil compounded with lard and inactive sulfur for the lighter operations or where the machine tool may require it.
3. A soluble oil adapted to the kind of water used, for emulsions to be used usually on the lighter operations, and particularly with the harder cutting tool material.

Soluble Oil As Cutting Fluid

In the search for a proper metal-cutting fluid it was found that some operations required a coolant more than a lubricant and Taylors' comprehensive work with his definite references to water as a cooling medium demonstrated that with some modifications, water could be used safely and efficiently as a cutting and grinding fluid.

Water is one of the most effective cooling agents known. Volume for volume, water is about twice as effective in carrying away heat as mineral oil. Water alone, however, is unsuited as a cutting fluid because of its rust and corrosive tendencies, and its lack of good friction-reducing properties. If mineral oil is emulsified in water the cooling ability of the water is impaired because of the difference in the specific heats of water and oil, and one of the main considerations in developing an effective cutting fluid is to combine high cooling ability, such as that provided by water with the effective friction-reducing ability of oil, without impairing either function.

Soluble oils are in a different classification than cutting oils as they are not used as received from the purveyor. They are mixed with water in different proportions, and the emulsions thus formed are the cutting fluids.

The base employed must be of such a type that either hard or soft water may be used, and without the necessity of heating the water before emulsification.

Although normally called soluble oils, they are not really soluble, but go into an emulsified state where tiny globules of the oil are completely surrounded by and widely dispersed, in the water. The mixture assumes a white, milky appearance.

Soluble oils should always be added to the water—the water should never be added to the oil. The "raw" oil should be added to at least four times its volume of water. Unless sufficient water is used, the emulsion may invert and become droplets of water, surrounded by oil, instead of droplets of oil surrounded by water. An inverted mixture can easily be detected by its slimy, or pasty, appearance and should be discarded.

An inverted mixture is a poor coolant and addition of water will not correct the condition. The only solution is to clean the system thoroughly and start with a new mixture.

Three types of soluble oils are in general use today:

1. Mineral oil compounded with a neutralized sulfonated oil, either from fixed or petroleum oils.
2. Mineral oil compounded with an alcoholic solution of soap.
3. A paste made from a thick soap solution, with or without oil.

When petroleum sulfonates are used, the first class is comparatively easy to manufacture and offers a safeguard against rusting on iron and steel parts. The petroleum sulfonates add deter-

VARIABLES IN METAL CUTTING TOOLS

MATERIAL	EFFECTIVE ANGLES	
	GRINDING	SETTING
Carbon tool steels	Back rake	Working angles
High speed steels	Side rake	Setting
Sintered carbide	Side relief	Entering
	End relief	True rake
	Side cutting	Lip
	End cutting	Relief
	Tip radius	

FIG. 18. Variables in metal cutting tools.

The cutting tools vary greatly. The material from which they are made and the type of work to be done influences their shape and grinding angles vary with the metal to be cut. Even after the tool has been ground to the prescribed angles, a whole new series of variables develop as the tool is set, or secured in its holder in preparation for the cutting operation. As the work begins and wear on the tool begins, further series of variables take place until the end of the tool life.

TYPICAL SPECIFICATIONS

	SOLUBLE OILS		SOLUBLE PASTE	
COMPOSITION	SULFONATED TYPE	ALCOHOLIC SOAP TYPE	GRADE 1	GRADE 2
Free fatty material.....	2% max.	6–20% max.	None	40% min.
Water content.....	5% max.	7.5% max.	30–40%	35–50%
Mineral oil content.....	85% min.	70%	40–50%	None
Soap content.....	.....	.....	15% min.	15% min.
Ash.....	2% max.	3.5% max.	5% max.	5% max.

FIG. 19. Metal cutting fluids (soluble).

Soluble cutting fluids are available in liquid and paste form. The sulfonated type seems to be acceptable for all around performance and the new EP type soluble oils are of this class. The alcoholic-soap type soluble oils have proved sucecssful in many operations, but are not suitable for use with all plant water. The soluble paste type is the least desirable and is harder to handle in the plant from a mixing standpoint.

CUTTING FLUID RECOMMENDATIONS.

Order of severity	Operations	Tool	For easier cutting iron and steel — Type of compounding	Tool	For harder cutting iron and steel — Type of compounding		For other easier cutting metals
							Magnesium alloys
1, 2	Broaching and pipe threading	HS	Lard; active sulfur (H, M)	HS	Lard; active sulfur; chlorine (H, M)	(1-10)	HS Light mineral oil
		HS	Lard; inactive sulfur (H)	HS	Lard; active sulfur (H)		CC Light mineral oil
		HS	Soluble oil and water	CC	Lard; inactive sulfur (H)		Aluminum
		CC	Soluble oil and water	CC	Soluble oil and water	(1-10)	HS Concentrate and kerosine
3	Tapping and threading (Plain)	HS	Lard; active sulfur (H, M, L)	HS	Lard; active sulfur; chlorine (H, M)	(6-10)	HS Soluble oil, water and kerosine
		HS	Lard; inactive sulfur (M)	HS	Lard; active sulfur (H, M)	(6-10)	CC Soluble oil and water
4	Gear cutting, gear shaving, and reaming (plain)	HS	Lard; active sulfur (H, M, L)	HS	Lard; active sulfur; chlorine (H, M)		Brass and bearing bronze
		HS	Lard; inactive sulfur	HS	Lard; active sulfur (M, L)	(1-10)	HS Lard and mineral (H, M, L)
		CC	Lard; inactive sulfur (M)	CC	Lard; inactive sulfur (H)	(6-10)	CC Dry
5	Drilling (deep), gun drilling	HS	Lard; active sulfur (M, L)	HS	Lard; active sulfur; chlorine (H, M)		Zinc
		HS	Lard; inactive sulfur (M)	HS	Lard; active sulfur (H, M, L)	(1-10)	HS Soluble oil and water
		HS	Soluble oil and water	CC	Lard; inactive sulfur (H)	(6-10)	CC Soluble oil and water
		CC	Soluble oil and water	CC	Soluble oil and water		Numbers in parentheses refer to order of severity
6?	Milling and boring, multiple spindle automatic screw machines, and turret lathes: drilling, forming, turning reaming, cutting off, tapping and threading	HS	Lard; inactive sulfur (H, M, L)	HS	Lard; active sulfur (L)		For other harder cutting metals
		HS	Soluble oil and water	HS	Lard; inactive sulfur (M)		Copper and gun metal
		CA	Soluble oil and water	CA	Lard; inactive sulfur (L)	(1-10)	HS Lard and mineral (H, M, L)
		CC	Soluble oil and water	CC	Lard; inactive sulfur (L)	(6-10)	HS Soluble oil and water
				CC	Soluble oil and water	(1-10)	CC Soluble oil and water
8, 9	High speed, light feed automatic screw machines: drilling, forming, tapping, threading, turning, reaming, box milling, and cutting off, drilling, planing, shaping and turning	HS	Lard; inactive sulfur (M, L)	HS	Lard; active sulfur (L)		Everdur (silicon bronze)
		CA	Soluble oil and water	HS	Lard; inactive sulfur (M)	(1-5)	HS Lard and mineral (H, M, L)
		CC	Soluble oil and water	HS	Soluble oil and water	(6-10)	HS Soluble oil and water
				CA	Lard; inactive sulfur (L)	(1-10)	CC Soluble oil and water
				CA	Soluble oil and water		Manganese bronze
				CC	Soluble oil and water	(1-5)	HS Lard and mineral (H)
10	Sawing		Soluble oil and water		Lard; inactive sulfur (L)	(6-10)	HS Lard and mineral (H, M, L)
			Lard; inactive sulfur (L)		Soluble oil and water	(1-10)	CC Soluble oil and water
10	Grinding		Soluble oil and water		Soluble oil and water		Nickel, monel metal, and inconel
10	Thread grinding, etc.		Lard; active sulfur and chlorine with light mineral		Lard; active sulfur and chlorine with light mineral	(1-10)	HS Lard; active sulfur (L)
						(1-10)	CC Soluble oil and water

Tool material
HS—High speed steel
CA—Cobalt alloys (stellite)
CC—Cemented carbide

Strength of compounding
(H)—High
(M)—Medium
(L)—Low

gency to the soluble oil mixture, offer greater cleansing action for the machine parts and considerable aid in deep drilling operations.

The second type requires less technical skill in compounding and less expensive equipment to manufacture.

The paste type, represented by the third classification, offers the least desirable finished product.

Typical specifications for these products are:

	Soluble oils		Soluble paste	
Composition	Sulfonated type, per cent	Alcoholic soap type, per cent	Grade 1 per cent	Grade 2 per cent
Free fatty material	2 max.	6-20 max.	None	40 max.
Water content	5 max.	7.5 max.	30-40	35-50
Mineral oil content	85 min.	70	40-50	None
Soap content	—	—	15 min.	15 min.
Ash	2 max.	3.5 max.	5 max.	5 max.

Soluble oil should be a clear, homogeneous, stable oil; free from disagreeable odor, sediment, and ingredients injurious to persons using it, either in the original state or in emulsions. The soluble oil should contain no materials that will cause corrosion of steel, copper, or copper alloys. The stability of the soluble oil should show no appreciable evidence of separation when subjected to cold weather conditions.

The soluble oils should emulsify with water readily and form stable emulsions when thoroughly mixed in the proportions of one part of soluble oil with 15 parts of distilled water. After 24 hr of standing at room temperature in a 4-oz. sample bottle it would show no appreciable oil or cream separation. For special hard water areas a hard water emulsion test is also recorded.

Emulsions of soluble oil should not have a tendency to foam excessively. The residue from emulsions of soluble oil should be soft in nature and free from hard, gummy residue. Soluble oils should not be rancid, either in their original state or in emulsion.

Some soluble oils contain water softeners as additives and may be mixed directly with almost any water commonly used in industry but without such additives, only soft, or treated water may be used. Soft rain, lake or river water, where available, presents no problem. Hard well waters (300 to 700 ppm hardness), however, containing minerals, salts, etc., may offer some difficulty in preparing uniform, stable emulsions. Soft water contains 50 to 170 ppm or 3 to 10 grains hardness per U. S. gallon. Hard water may contains 300 to 700 ppm or 16 to 40 grains hardness per U. S. gallon and should be treated before attempting to mix with soluble oil to form emulsions. The ratio of water to oil in the emulsion is adjusted to suit the conditions of service and varies from one part oil to from 10 to 100 parts water.

The importance of cleanliness in handling emulsions cannot be overstated because soluble oil emulsions are very susceptible to contaminants. Bacteria may infect inactive equipment, even during short periods of idleness, and for this reason the oil sump, and entire system should be periodically cleaned out. If the presence of bacteria is suspected, the system should also be flushed with a germicidal solution. Dirt, chemical, food particles, oil, grease, or other refuse must not be allowed to get into the emulsion. Metal chips, grinding grits, and dirt formed in the metal working operation may be carried into the coolant system and eventually affect the stability of the emulsion. Regular and thorough cleaning is necessary for efficient operation.

In addition to reducing operation costs, soluble oil emulsions are used where the operation requires large heat absorption and removal. Some heavy duty operations generate enough heat at the tool to evaporate the water at a high rate and if unchecked, will result in changing the oil to water ratio so that in extreme cases, all the coolant in the system would be lost, the water evaporating and the oil carried away by the fabricated pieces and chips.

In grinding operations the oil is carried away by the pieces so that the emulsion concentration becomes leaner with service. In extreme cases rusting of machine and parts may occur.

Emulsions, as coolants, are usually prepared in the proper recommended concentration for given applications. In service, the concentrations may not remain constant, either through loss of water from evaporation or to loss from carry-off. In order to maintain the proper concentration of fluid some control method should be adopted enabling rapid determination so that water or soluble oil may be added as required.

Iron and iron salts are present in the water at many industrial plants and has an important effect on the rust accelerating characteristics of the finished mixture. When such water is evaporated from the surface of the fabricated parts, the iron salts are frequently deposited in a form which turns to oxide and promotes rust.

Algae, bacteria, and other organic matter found frequently in natural waters can affect the mixture objectionably. Bad odor, separation, and rusting are frequently traceable to these sources.

Many salts are found on the surface of metals, particularly forgings and castings, which are water-soluble and wash off to accumulate in the cutting fluid. A

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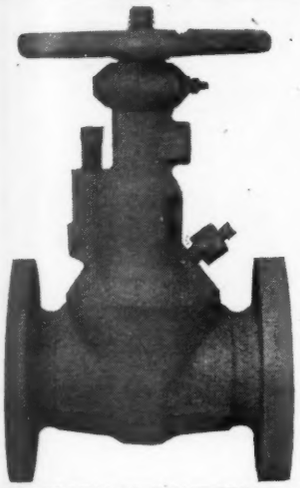

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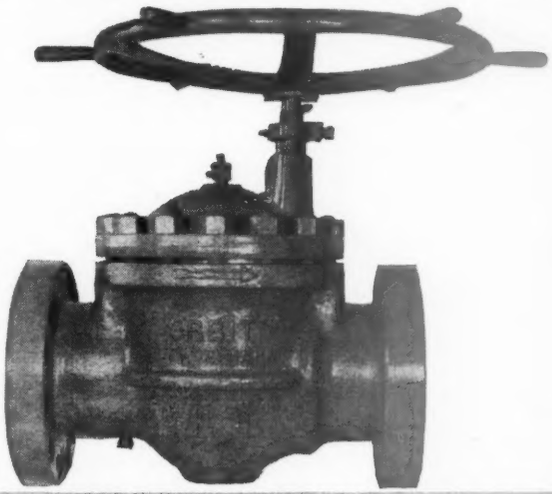
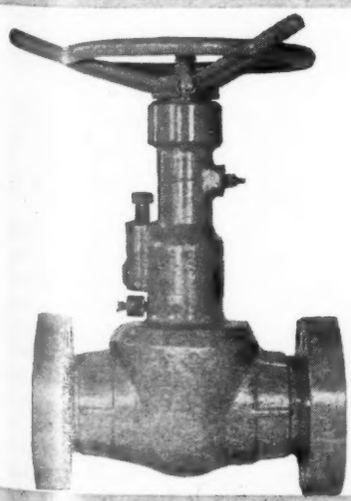


L. P. GAS SERVICE



The Orbit resilient, friction free seating principle is a natural for holding liquefied petroleum gases. Regardless of minor body deflections, contraction or expansion brought about by fluctuating temperatures or pressures, the Orbit seating principle is not affected. No lubricant of any kind is required in the valve body to effect a shut-off; therefore maintenance of Orbit L. P. Gas Valves requires a minimum of expense and attention. Orbit L. P. Gas Valves also feature an all forged steel body and bonnet plus welded bonnet construction and adjustable reliable plastic stem packing — This combination makes the Orbit L. P. Gas Valve the "last word" in safety and dependability. The use of Orbit L. P. Gas Valves is your assurance against fluid contamination. You can buy Orbit Valves with confidence because they are designed to handle your hard-to-hold hydrocarbons and vapors.

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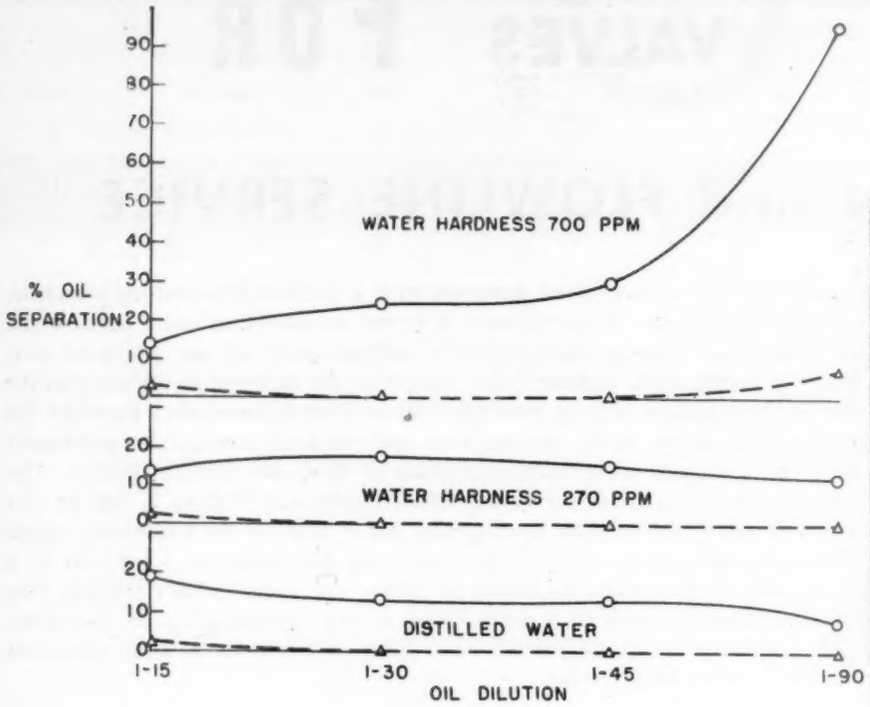

FIG. 20. Soluble oil emulsion separation tests.

The effect of water hardness on emulsion stability is shown by these curves, which represent the performance of two types of soluble oil emulsions in water of two different degrees of hardness, as compared with distilled water. The oils tested were selected by ASTM Technical Committee K and was reported by Section 1, Sub-Section on Physical Tests.

REFERENCES: *Emulsion Stability Test Methods for Soluble Oils*, ASTM Technical Committee K, Section 1, Sub-Section on Physical Tests—No. M 51-639, October 8, 1951.

FIG. 21. EP soluble oil.

This cluster gear for Case tractor was roughed out on a No. 7 Fellows gear shaper and finished on a No. 7A Fellows gear shaper from 4620 steel, using EP soluble oil an a 10 per cent emulsion. The tool life was 55 units per grind and considered very good because this emulsion was used to replace a lard-oil-sulfur cutting oil. The emulsion was prepared with untreated well water showing 324 parts per million hardness.

very small amount of contamination is required to neutralize the effect of the emulsifier and produce difficulty.

Cemented carbide tools permit higher cutting speeds but tremendous heat is released because of the greater weight of metal being removed. Soluble oils are favored in these operations because of their good coolant properties. It is necessary, however, to direct the stream of emulsion against the work so that the tool is not shielded by the chip being removed. If the flow of emulsion does not bathe the working edge of the tool constantly, intense heat develops, raising the temperature of the tool dangerously high. When the chip breaks off or the cutting action ends, the sudden deluge of relatively cool emulsion produces cracks in the carbide insert and the edge of the tool begins to disintegrate. The stream of coolant should be directed to enter beneath the chip and keep the tool constantly and evenly cooled. High pressure streams of coolant should be carefully avoided wherein the liquid hits the work at high velocity and splashes. This condition does not permit effective heat transfer. In short, eliminate all restrictions, deliver a large volume of coolant at low pressure so that it forms a fluid ball around the active edges of the tool and thus has ample opportunity to absorb heat effectively.

The individual mixtures for specific jobs vary widely according to the job, rust-preventing character of the metals being machined, and the lubrication requirements of the machine. The finishes obtained are generally as good as with cutting-oils. The richer mixtures of 10 and 20 per cent are used for broaching and pipe threading the easier cutting iron and steel material. The 4 and 5 per cent emulsions are generally satisfactory for milling and boring, multiple spindle automatic screw machines, and turret lathes; drilling, forming, turning, reaming, cutting-off, tapping, and threading all ferrous metals where cemented carbide tools are used. The leaner mixtures are also suitable for high speed light feed automatic machines for iron and steel, and for both easier and harder cutting metals when Stellite, or cemented carbide tools are used. Use emulsions of 4 per cent soluble oil for sawing and plain grinding of these ferrous metals.

Lean mixtures are used for grinding as excessive oil in the richer mixtures will clog the pores of grinding wheels and cause them to skid instead of grind. The grit size of the wheel must be taken into consideration as wheels with coarse grit make a heavier cut, and, therefore, requires a richer mixture than a fine grit wheel in order to produce the desired finish. The grinding of harder metals requires less lubrication and more heat dissipation as there is less tendency for the metal to wipe or draw. Therefore, a much higher ratio of water to oil should be employed. In order to maintain the desired finish, the grinding wheel must be kept clean, so the stream of emulsion should be directed against its surface with sufficient force to dislodge the minute chips, wash them from the wheel, and prevent it from picking up dirt and grindings. A wheel loaded with dirt and grindings becomes glazed and will not cut cleanly. As a further aid in maintaining a clean grinding wheel, a reservoir of adequate capacity, should be provided and fitted with sufficient baffles to enable the minute chips to settle out of the emulsion. A wetting agent should be incorporated in the emulsion to reduce its surface tension, which is normally equal to that of water. This wetting ability also aids in dissipating heat from the work-piece and by wetting the chips, allows them to settle out of the emulsion quickly.

A soluble oil may perform satisfactorily in grinding operations yet may not pass the supreme test of stability of emulsion because of the condition of the water used.

Anti-foam addition agents are added to soluble oil to stop formation of foam. Foaming causes trouble in pumping and a fluid that is full of air bubbles cannot perform its functions of cooling and anti-welding. In grinding operations, foaming carries over metal particles that load the surface of the grinding wheels and causes burning and checking on the parts. Anti-foams do a good job in preventing lather caused by aeration of the emulsion, keeping it from frothing out

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(a) breaking existing plant bottlenecks

(b) full new plant capacity at lower cost

(c) long tray life, easy maintenance

SHELL's simple Turbogrid tray offers outstanding advantages in performance and cost . . . advantages that result in much **higher capacity** and in operating economy. Performance has been fully *proven* in many commercial installations.

Turbogrid trays **increase throughput in existing towers,** or deliver required throughput at lower cost in new plant construction. The greatest capacity advantages are obtained with critical separations, such as depropanizers and stabilizers. Still other advantages are lower column holdup and pressure drop, as well as easier column control.

Simple construction assures lower fabrication, installation and maintenance costs and easier accessibility to all parts of the tray. Standardized design permits use of **corrosion-resistant alloy trays at no extra cost.**

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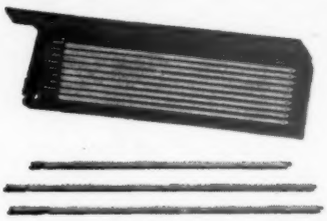
—have readable, dial-type scales and corrosion-resisting stainless steel stems—stem lengths from 2" to 24"—ranges from low as −100°F. to high as 1000°F.—accuracy ½ of 1% of thermometer range.



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—certified sets of ASTM Testing thermometers with overlapping ranges in protective case. Ranges from −36°F. to high as 760°F. Also precision and standard etched stem thermometers for general testing.

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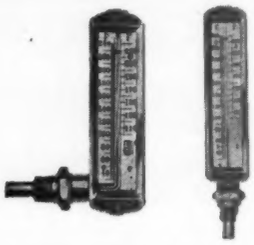


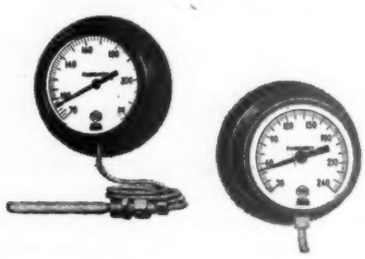
GLASS (Metal Case)

—available in all forms, all ranges, stem lengths and connections. Accuracy within one scale division. Also submarine types, metal and cupcase thermometers.

Remote Reading

ELECTRICAL

—resistor bulb sensing element permits mounting indicator any distance away from point of measurement. *Multiple* remote readings also possible by use of selector switch and several bulbs.



PRESSURE ACTUATED

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WESTON *Temperature Instruments*

— TO INDICATE — RECORD — CONTROL

9413

of the reservoir, effecting longer tool life, and producing better surface finishes.

In the past several years, emulsions have been used in certain operations where the design of the machine allowed the coolant to enter the lubricating oil system, causing sludging of the lubricating oil and resulting in bearing failures. Either the machine should be corrected mechanically, to prevent the coolant entering the lubricating system or an emulsion should not be used. Nor should lubricating oil leak from the bearings into the soluble oil emulsion.

Soluble oil emulsions have no odor and women operators like them as they soften their hands. The pieces are cooler and easier to handle. Clothes do not become stained.

Germicides may be added to soluble oils in the machines, generally in the ratio of one part germicide to 600 parts emulsion. It should be renewed every two weeks.

New EP soluble oils are showing excellent performance in a wide variety of applications. Certain very severe cutting operations on alloy steels for jet engines have show that EP soluble oils are the only really satisfactory cutting fluids for such machining operations.

Summary

The two most important functions of metal-cutting fluids are lubrication and cooling. Lubrication maintains the cutting tool in good condition and reduces friction at the chip-tool interface. It also contributes to the uniformity of finish and reduces power consumption. Cooling protects the tool from becoming overheated, lengthening its useful life; it contributes to uniformity of finish and dimensions of parts, and to the comfort of operators in handling the finished parts by reducing their temperature.

Additional features will be found in the many newer types of cutting oils available, which were designed for various combinations of cooling, lubricating, film-forming, anti-rusting, and anti-corrosion properties desired for the different metals, operations, production rate, surface finish, and useful tool life. There are also three general types of soluble oils available that are quite distinct from the cutting oils and are indicated for operations requiring predominantly cooling effects, although they possess ample lubricating properties as well.

Cleanliness and good housekeeping cannot be stressed too much, these become "musts" in the production shop because surface finish and tool life are affected by cutting fluids containing fine chips, dirt or grindings.

Disagreeable odors indicate activity of certain types of bacteria, decomposition of food particles or other refuse thrown in, or allowed to contaminate the fluids. Bacteria are not present in soluble oil but may be found in the water that is used for emulsification. If suspected of contamination, the system should be cleaned thoroughly and a new start made using fresh fluid. * * *

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Rockwell 100 in., 1,000 lb. orifice meters on gas lift header. Manifold in center of picture is controlled with Nordstrom Hypreseal valves.

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You gain in many ways by using Rockwell orifice meters. The precision engineered, sturdily built mechanism records static and differential pressures exactly as they occur. All operating parts are of heavy stainless steel . . . *made to last!* Routine servicing is easier, too, due to the accessibility that has been built into this design. And with the Rockwell unit manometer construction you can interchange the high side chamber with other chambers of higher or lower range, thus sparing the expense of stocking complete meters.

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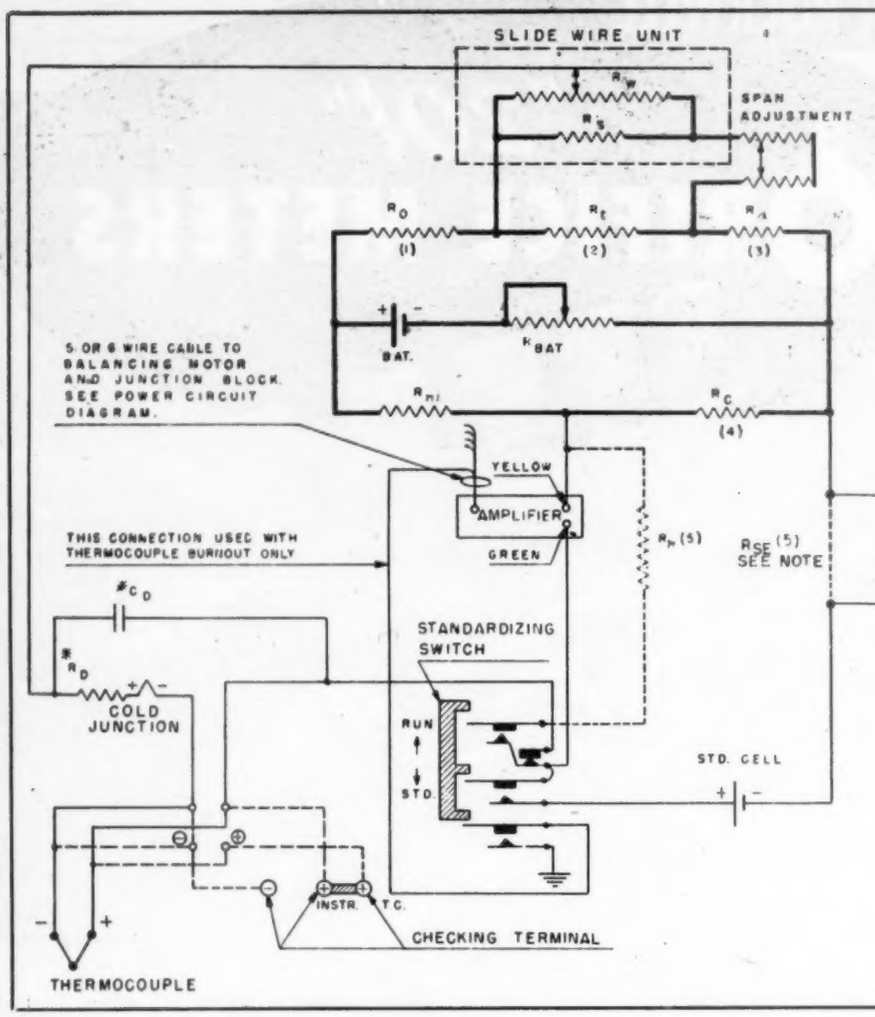


FIG. 1. Schematic wiring diagram *ElectroniK* potentiometer.

NOTES:

For measuring thermocouple E.M.F. or checking instrument remove jumper bar between terminals "T.C." and "Instr."

Numbers in parentheses adjacent to resistors refer to locations on spool mounting plate.

"R_S" shunt is mounted on slide wire.

*"R_D" and "C_D" — damping resistor and capacitor.

When checking terminals are used, the thermocouple is connected to lower terminals as shown by dotted lines instead of upper terminals and the checking terminals are connected internally as shown by dotted lines.

When circuit indicated by dashed lines is used, R_{SE} is omitted.

EXCLUSIVE

Trends in Refinery INSTRUMENTATION

PART 3 — Factors in maintenance of continuous balance potentiometers

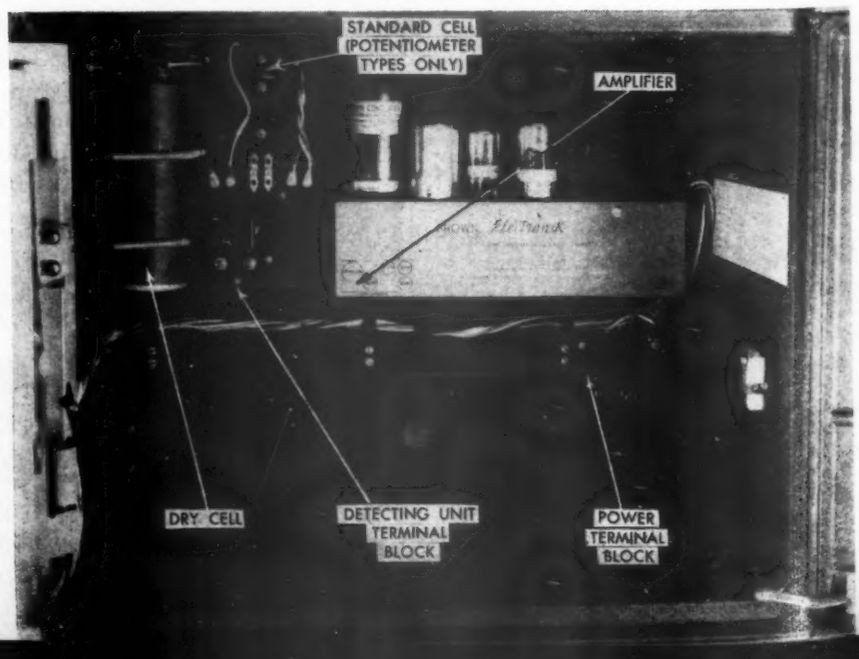
S. D. ROSS* and J. PROCOPI*

THE subject of instrument maintenance and service as applied to electronic potentiometers is one of considerable interest to petroleum processors. In currently expanding petroleum technology, productive output is influenced to a considerable degree by the performance of thousands of continuous balance potentiometers, with the number of units employed increasing at an unprecedented rate.

It is somewhat amusing to reflect that the introduction of these electronic instruments fostered a notion that, in order to keep them in first-class operating condition it would be necessary to employ instrument men highly trained in the field of electronics. This notion has been dispelled by over a decade of ex-

*Brown Instruments Division of Minneapolis-Honeywell Regulator Company.

FIG. 2. Inside of case, strip chart recorder.



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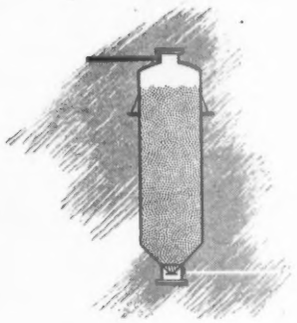

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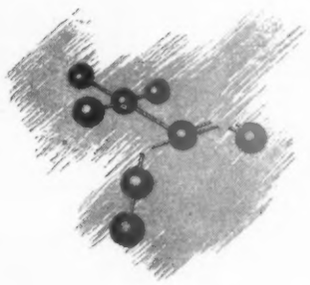
Attapulgus or Porocel sorptive minerals are recognized standards in desulfurization, reforming and isomerization systems—catalytic removal of unsaturates—conversion of sulfides to elemental sulfur—fluid catalyst applications—as catalyst carrier in copper sweetening processes.



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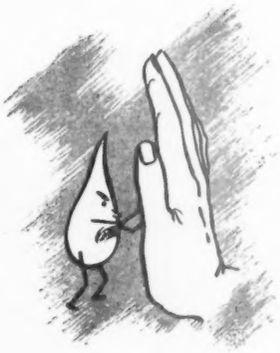

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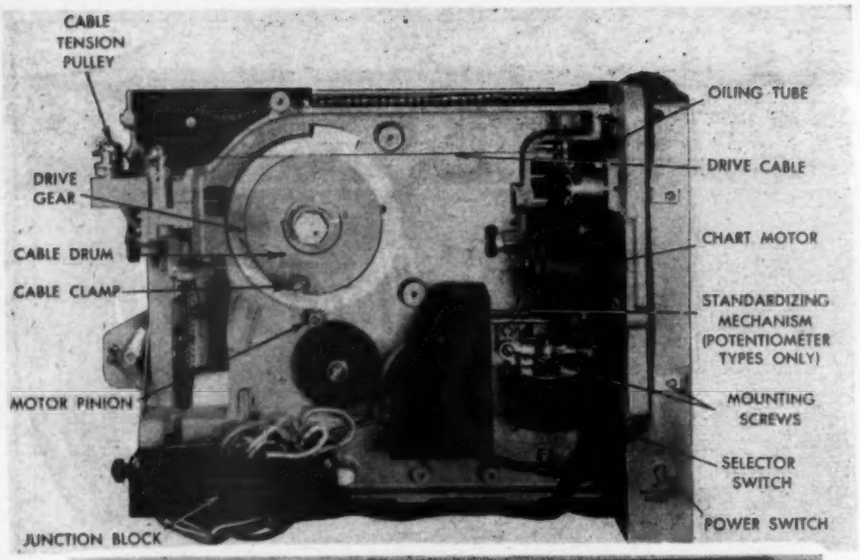

FIG. 3. *Top,* rear of chassis, strip chart recorder.

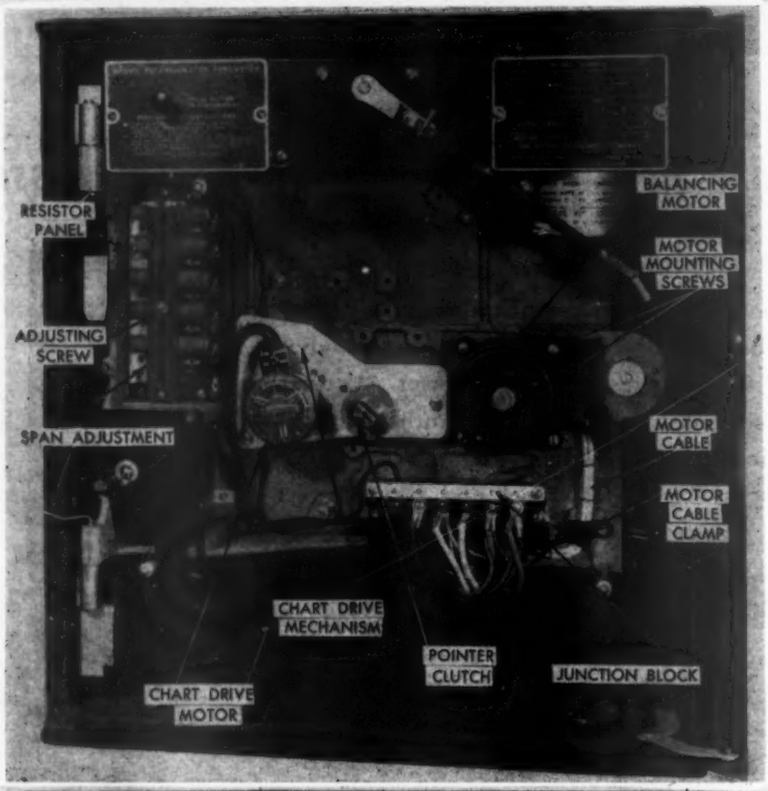

FIG. 4. *Center,* recorder with chart plate and resistor cover removed.

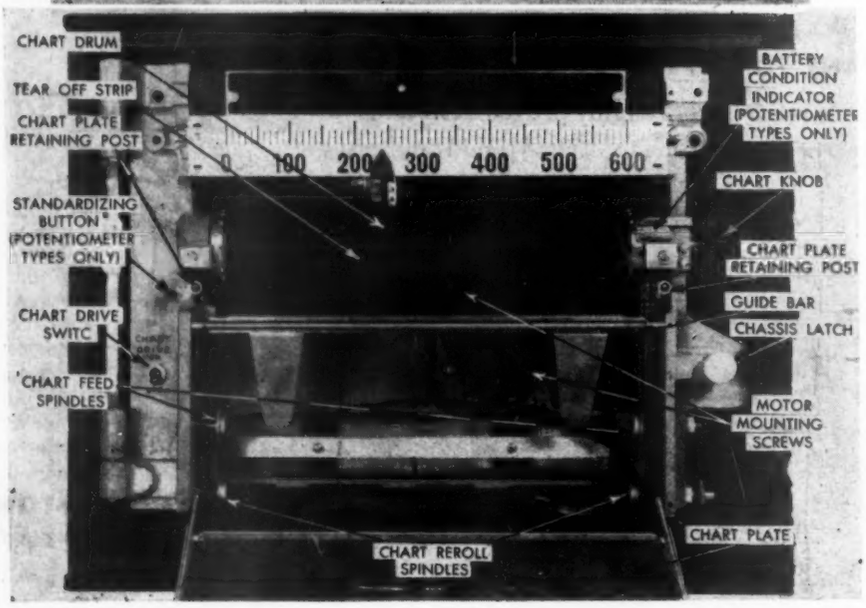

FIG. 5. *Bottom,* strip chart recorder with chart removed.

perience. It has been found that through a program of regular inspection and preventive maintenance, these instruments will supply practically trouble-free operation. When operational failures do occur, maintenance is reduced to a relatively simple system of checks. Absence of numerous levers, gears and other mechanical components in electronic instruments facilitates the isolation of trouble. Correction of any difficulty is further simplified through color-coded wiring, clearly marked and easily accessible terminal blocks, and completely interchangeable and easily replaceable components.

Preventive Maintenance

In many refineries, servicing of continuous-balance potentiometers, except for pen and chart servicing, is effected when instrument malfunctioning occurs, or when a processing unit is shut down periodically. Management in these plants, in weighing costs of increased instrument personnel required for periodic checking against increased cost of maintenance required through neglect of preventive measures, have decided that increased maintenance is less expensive than increased instrument manpower. This seems to be a minority opinion.

The majority of petroleum processors seem to have accepted as truth the adage that "an ounce of prevention is worth a pound of cure." In these majority plants, instruments are usually inspected once each day, with the inspector's ear tuned for any warning of shafts or bearings in need of lubrication. Drive gears and pinions are checked for signs of wear. In contaminated atmospheres (sulfur, gas, etc.) thermocouples and thermocouple switches, if any, are examined and checked frequently to ensure that they are clean.

Depending upon the application and usually at monthly intervals, the print wheel ink pads on multiple-record instruments are resaturated so that a clear, legible record is to be obtained. Where high ambient temperatures prevail, balancing motors are disassembled periodically in order that the lubricant can be changed.

Calibration of these instruments is checked at frequent intervals, unless duplicate measurements are being employed, and these agree. Finally, at yearly intervals, the drive gear shaft and needle bearings are cleaned with cleaner's naphtha, and the needle bearings repacked with the prescribed lubricant. At the same intervals, or more frequently, standardizing switch contacts are cleaned with a stiff brush and cleaner's naphtha, to assure correct calibration and instrument operation.

The extent of these preventive maintenance measures, and others employed

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The two most common bottlenecks encountered, when increased production is desired, have been eliminated by making the initial capacity of the blower 30% greater than required for the carbon burned at design conditions and installing a fractionating column one foot larger in diameter than required for design capacity. At a later date throughput can be increased to the ultimate capacity of the blower and tower by changing pumps and adding heat exchange surface.

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by petroleum processors, is determined largely by factors as size of instrument departments and the nature of an installation.

Testing and Trouble Shooting

The dependability of this continuous balance unit and the lack of any requirement for major field servicing is illustrated by a recently conducted survey which revealed that of over 50,000 of these units in service over a period of 10 years, less than 3 per cent have required major repairs or replacement. Nevertheless, malfunctions occur, and the cause of these must be isolated quickly. A procedure for general testing and trouble isolating is outlined in the following sections.

Equipment Required for Isolating and Checking Defects. In order to make the checks described below, three pieces of test equipment are required, namely: (1) a multi-range test meter, (2) a portable potentiometer and (3) a decade resistance box. The test meter should be accurate to ± 2 per cent, with a-c and d-c voltage ranges to 1000 v and a sensitivity of 20,000 ohms per volt d-c, 1000 ohms per volt a-c. The ohm meter's range should permit measurements between 1 ohm and about 5 megohms. It should have an output meter arrangement so that a-c voltages can be measured independently of any d-c component which may be present. The output meter consists of a condenser in series with the a-c voltmeter.

The calibrated accuracy of the portable potentiometer should be approximately ±0.035 mv for ranges from 0 to 11 mv and ±0.070 for ranges from 11 to 71 mv. A potentiometer of this accuracy is adequate for operational checks and calibration adjustments in most industrial applications. For highly accurate calibration adjustments, a laboratory type potentiometer should be employed.

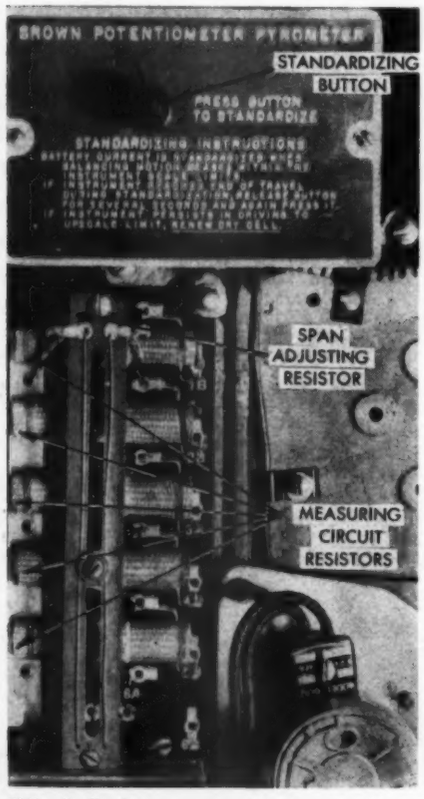


FIG. 6. Resistor compartment, circular chart recorder.

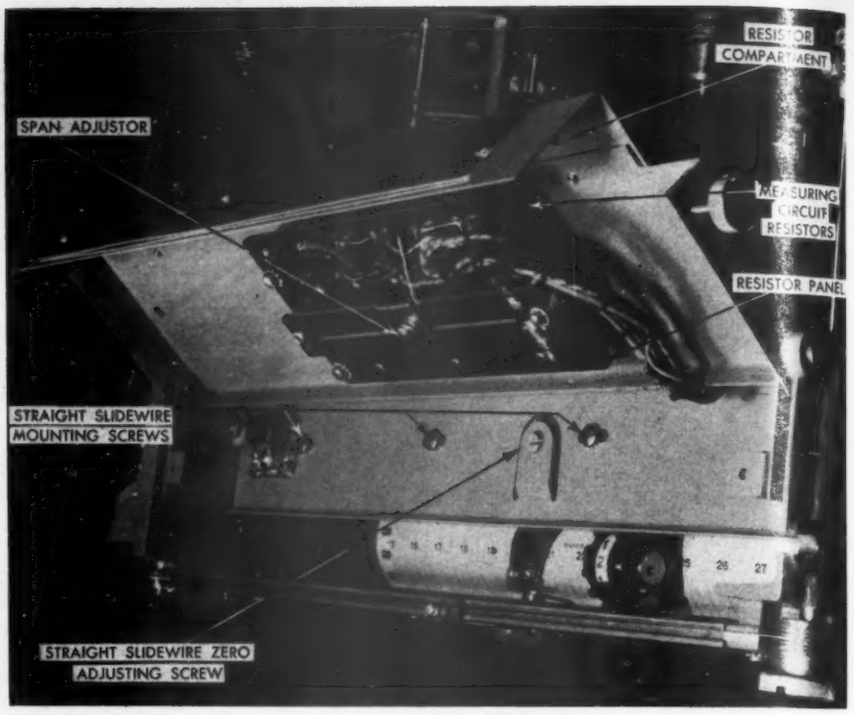


FIG. 7. Resistor compartment, strip chart recorder.

The decade resistance box should have dials for hundreds, tens, units, and tenths of ohms. Calibrated accuracy should be 0.1 per cent for resistors of 1 ohm or more, and 0.25 per cent for resistors of 0.1 ohm.

Isolating the Measuring Circuit. Where either erroneous readings or sluggish and irregular pen drives exist, or if no drive occurs, a simple test method can be utilized to isolate the difficulty into any one of three main sections, namely, (1) measuring circuit, (2) amplifier, and (3) balancing motor.

In order to isolate the measuring circuit, an electrical checking procedure can be used, as follows:

(1) Disconnect yellow and green amplifier output leads from the terminals, as illustrated.

(2) Connect a portable potentiometer to the green and yellow terminals of the thermocouple block.

(3) Short the thermocouple terminals.

(4) Take any point in the temperature scale of the instrument, (for example, 200 F in a 0-500 F scale), and convert this temperature to emf equivalent for the thermocouple in use. Thermocouple compensation must be taken into consideration.

(5) Set the portable potentiometer for this value of emf.

(6) With power off, rotate by hand, the large drive gear (illustrated) on the rear of the chassis until the galvanometer balances. If balance occurs at a point other than the check position (200 F) then the measuring circuit is functioning improperly and should be checked (see "Trouble Shooting of Measuring Circuit"). If balance occurs

FIG. 8. Right side of chassis, strip chart.

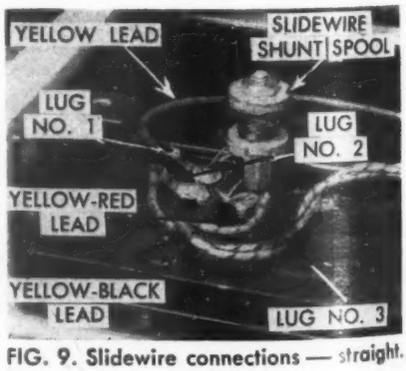
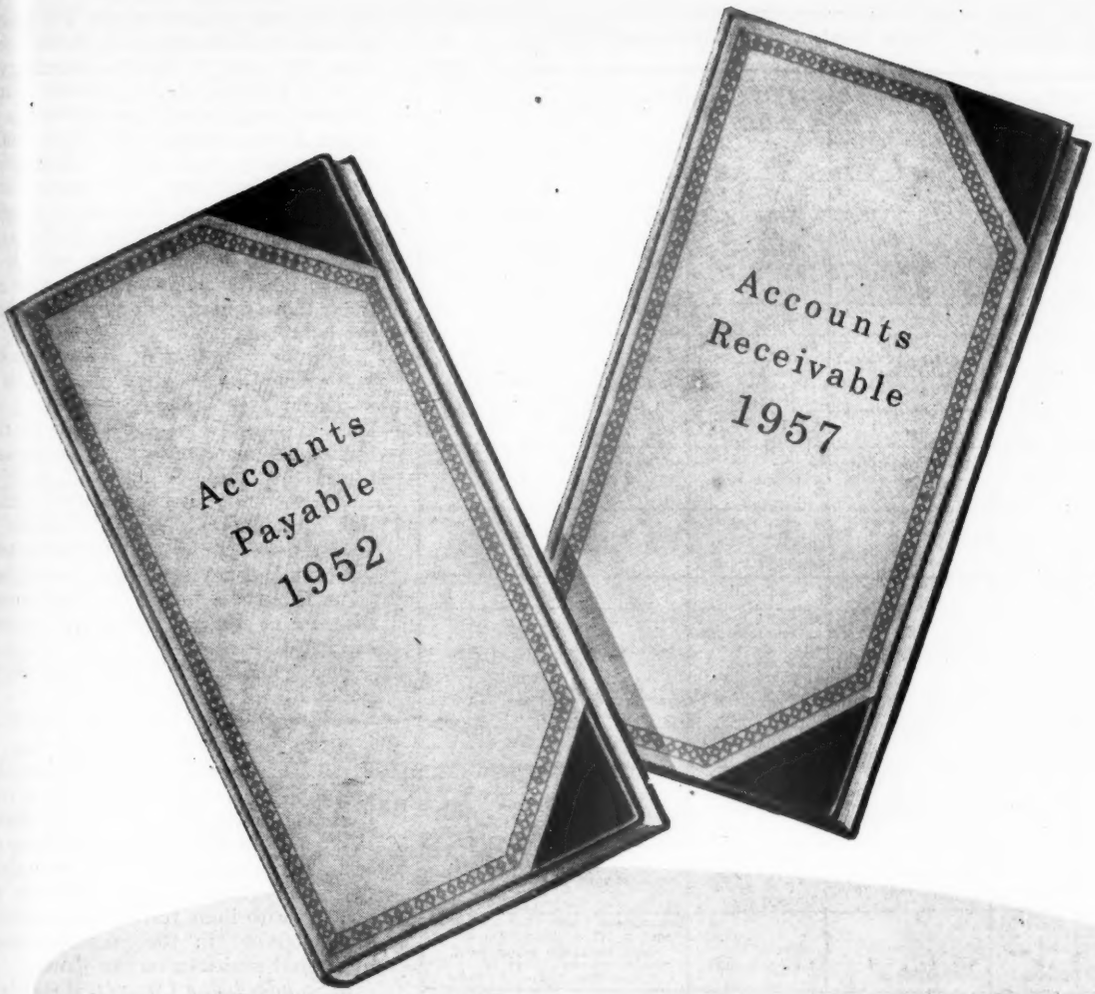


FIG. 9. Slidewire connections — straight.



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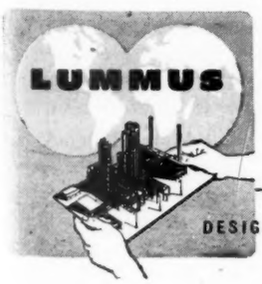

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DESIGNING ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM AND CHEMICAL INDUSTRIES

TABLE 1. Resistance check continuous balance amplifier.*

Location	Measure From Terminal	Measure To Terminal	Component(s) Measured	Correct Approximate Resistance	Recommended Corrective Action If Resistance is Incorrect (See Text Also)
Tube Sockets 1, 2, 3, 4	1	8	Power Transformer Filament Winding and Filament Wiring	0.2 ohm	Check wiring. Replace power transformer, if necessary.
Tube Socket 1	7	Ground	Cathode #2 Connection	Dead short	Resolder connections
	2	7 (Ground)	R-2 and C-5.	10,000 ohms ±10%	Check R-2 and C-5 separately. Disconnect 'P' lead of C-5 to Check: C-5 should measure over 1 megohm. Observe caution given in text when checking condensers.
	3	5	C-2	over 1.0 meg.	Replace C-2
	4	7 (Ground)	Secondary of input transformer R-13, C-1	6000 ohms ±10% Input transformer secondary-6500 ohms R-13-0.1 megohm C-1-over 1.0 meg.	Disconnect R-13 and C-1 and check separately Replace the input transformer if necessary.
	5	7 (Ground)	R-3	1.0 meg ±10% or 1.2 meg ±10%	Replace R-3
Tube Socket 1	6		C-3 with sensitivity control at clockwise limit	over 1.0 meg	Replace C-3
Tube Socket 2		4			
Tube Socket 1	6		R-4, R-10	R-4=1.0 meg or 1.2 meg R-10=47,000 ohms Total R=1.05 megs	Check R-4, R-10 separately. Replace defective resistor.
Tube Socket 2		5 or 7			
Tube Socket 2	2	Ground	Cathode #1 Connection	Dead short	Resolder connection
	4	2 (Ground)	Sensitivity Control R-11	Variable from 0 at counterclockwise limit to 1.0 meg. at clockwise limit without breaks	Replace sensitivity control R-11
	5	7	Buss	Dead short	Resolder connection
	5 or 7	3	R-6	1.0 meg. ±10% or 1.2 meg. ±10%	Replace R-6
Tube Socket 2	5 or 7		R-10, R-9, R-1.	R-1=1.0 meg or 1.2 meg R-9=0.15 meg R-10=47,000 ohms Total R=1.2 meg. ±10% or 1.4 meg ±10%	Check separately and replace defective resistor.
Tube Socket 1		3			
Tube Socket 2	6	2 (Ground)	Rectifier winding of power transformer	50-60 cycle 440 ohms 25-40 cycle 550 ohms	Replace power transformer
Tube Socket 2	5 or 7	2 (Ground)	C-6, C-7, C-8 R-9, R-10	Over 1.0 meg.	Disconnect leads from multiple section filter condenser and check sections separately Observe caution given in text for checking C-6, C-7, C-8.
Tube Socket 2	3		C-4	Over 1.0 meg.	Replace C-4
Tube Sockets 3 and 4		4 or 5			
Tube Sockets 3 and 4	2	7	Cathode Connections	Dead Short	Resolder
Tube Socket 3	2 or 7		Cathode Connections	Dead Short	Resolder
Tube Socket 4		2 or 7			
Tube Sockets 3 and 4	2 or 7	Ground	Amplifiers without desensitizing 76020-Item or 351921-Item, R-5	50-60 cycles R-5=150 ohms 25-40 cycles R-5=300 ohms	Replace R-5
	2 or 7	Blue amplifier lead	Amplifier 351959-Item with desensitizing, R-5	50-60 cycles R-5=150 ohms R-12=1000 ohms	Replace R-5 or R-12 as required
	Blue amplifier lead	Ground	R-12	25-40 cycles R-5=300 ohms R-12=1000 ohms	

*Text mentioned is given at end of article.

at check point, proceed to "Test to Isolate Amplifiers and Balancing Motor."

Test to Isolate Amplifier and Balancing Motor. Assuming that the earlier outlined malfunction—either erroneous readings or sluggish and irregular or no pen drive still exists, and that the test outlined under "Isolating the Measuring Circuit" (above) has been completed, with balance occurring at the test point indicating no trouble in the measuring circuit, the amplifier is next isolated. This step can be effected by the following procedure:

(1) Disconnect the yellow and green input leads to the amplifier (Fig. 1).

(2) Connect a portable potentiometer to these leads.

(3) Connect a test meter (250 v a-c range) to the red and green terminals of the balancing motor (Figs. 4 and 5).

(4) Apply 2 or 3 mv to amplifier from the portable potentiometer. The output voltage from the amplifier should be at least 100 v a-c. It may be necessary to reverse polarity of the portable potentiometer leads in order to obtain the impulse. If the output is less than 100 v, check easily replaceable components, such as tubes, fuse, and converter. If output still is not obtainable, replace the amplifier. If amplifier checks satisfactorily, or if replacement unit is installed, and the original malfunction outlined above persists, the fault must be in the balancing motor.

Trouble Shooting of Measuring Circuit. When the isolation test reveals an improperly functioning measuring circuit, as outlined in a previous section, the various components of the measuring circut should be checked, thus:

a. *Continuity.* Break battery connection, disconnect reference junction resistor, and make continuity check without breaking any soldering connections. In making these checks, use a schematic diagram of the measuring circuit, such as that illustrated.

b. *Short Circuits.* Check grounds for possible short circuits.

c. *Bridge Resistor Circuit.* The resistors are numbered 1 to 5 and R_{BAT} in Fig. 1. On circular chart recorders they are panel mounted in the resistor compartment at the left side of the chassis (Fig. 6). On strip chart recorders, the resistor compartment is located above the scale (Fig. 7). All resistors are marked with their resistance, numbered and mounted in the correspondingly numbered positions on the panel.

d. *Standardizing Circuits.* If standardizing is steady, proceed to test as outlined under "Slidewire" below. If pen motion occurs on repeated standardizing, or if pen continually drives, indications are that there may be dirty contacts or windings in the standardizing circuit. In order to correct this difficulty, contacts and switches should be cleaned, as should the rheostat contacts. If

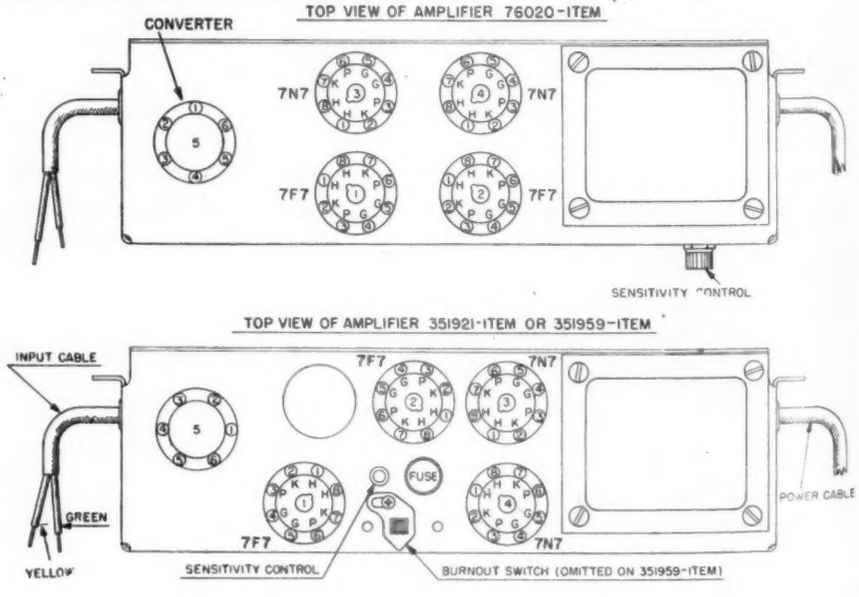

FIG. 10. Identification of amplifier tube socket terminals.

TABLE 1 (concluded). Resistance checks continuous balance amplifiers

Location	Measure From Terminal	Measure To Terminal	Component(s) Measured	Correct Approximate Resistance	Recommended Corrective Action If Resistance Is Incorrect (See Text Also)
Tube Sockets 3 and 4	4	5	Grid connections	Dead short	Resolder
Tube Socket 3	4 or 5		Grid connections	Lead short	Resolder
Tube Socket 4		4 or 5			
Tube Sockets 3 and 4	4 or 5	Ground	Amplifier 76020-Item, R-7, R-8, and "Burnout" section of Rectifier Winding, Power Transformer; Amplifier 351921-Item, with Burnout Switch in #1 position	0.16 meg. ±10%	Check separately and replace defective component.
			Amplifiers 351921-Item, with Burnout Switch in #2 position or 351959-Item, R-8	0.15 meg. ±10%	Replace R-8 or switch.
Tube Socket 3	3		Plate connections	Dead short	Resolder
Tube Socket 4		3			
Tube Socket 3	6				
Tube Socket 4		6			
Tube Sockets 3 or 4	3	6	Power transformer high voltage secondary	50-60 cycles 610 ohms 25-40 cycles 760 ohms	Replace power transformer.
	3 or 6	Red amplifier Lead 5 or 6-wire cable	Center tap of high voltage secondary	50-60 cycles 305 ohms 25-40 cycles 380 ohms	Replace power transformer.
Tube Socket 5	3	5	Primary of input	* ohms ±10%	Replace input transformer
	3 or 5	1,2,4,6	Tube Socket	Open Circuit	Check connections
	1	6	Filament winding of power transformer and filament windings	0.2 ohms	Check wiring. Replace transformer, if necessary
	2	1 or 6	Center tap of filament winding	0.1 ohm	Replace transformer
	2	Ground	Socket connections	Dead short	Resolder
	3	Green input lead	Center tap of input transformer	Ø ohms ±10%	Replace input transformer
	1,2,3,5, and 6	Yellow input lead	Tube Socket	Open Circuit	Check Connections
	4	Yellow input lead		Dead Short	Resolder
Amplifier cable 5 or 6 wire Amplifiers 76020-Item 351921-Item 351959-Item	Black	White	Power transformer primary and fuse line voltage connections	7.5 Ohms	Check fuse, switch, and transformer separately, replace defective component
	Green	Ground		Dead short	
Amplifiers 351921-Item 351959-Item 5 or 6 wire Amplifier cable	White	Yellow	C-10 Motor capacitor	over 1.0 meg	Replace motor condenser. Observe caution given in text when checking these condensers
	Red	Green	C-11	over 1.0 meg	

* 45 ohms for transformers with a Thordarson label
80 ohms for transformers without a manufacturer's label
56 ohms for #355567 transformer

Ø 22.5 ohms for transformers with a Thordarson label
39 ohms for transformers without a manufacturer's label
28 ohms for #355567 transformer

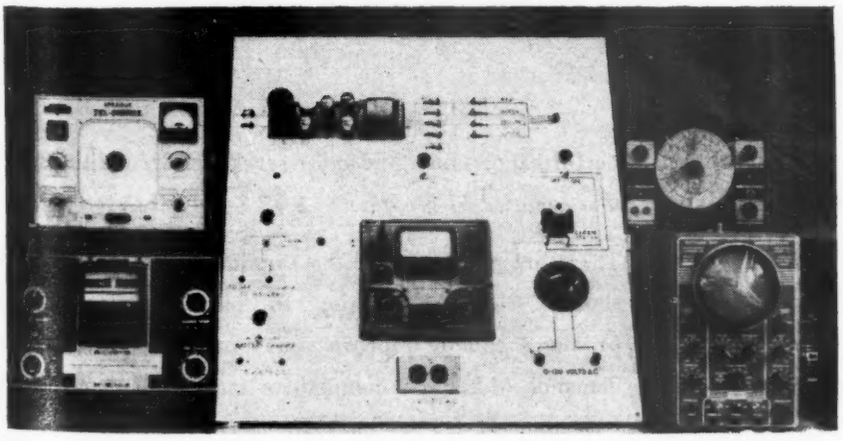

FIG. 11. Amplifier and balancing motor test equipment used in servicing electronic instruments at a large refinery. This board quickly provides "yes" or "no" findings enabling an instrument man to quickly find the source of any trouble. Other instruments shown are useful tools that are employed in tracking down defective components—comprising a tube tester, capacity tester, oscillograph, signal generator and multi-tester.

trouble still exists, check rheostat windings (upper left hand corner of circular chart potentiometer chassis, and at the back of strip chart chassis). If trouble persists, check balancing motor by procedure outlined below under "Balancing Motor."

e. *Slidewire.* Remove slidewire cover and check for grease or dirt on the windings. Check for worn contacts or improper tension on contact carrier. Finally check resistance of the slidewire, as follows: Helical slidewire—Swing instrument chassis out of the case, loosen the three screws in the slidewire terminal block (Fig. 8) and remove it. Connect an ohmmeter on its lowest range, between the center and right lug on the slidewire. If resistance does not read 20 ohms, replace the slidewire. Straight slidewire—Swing instrument chassis out of the case, swing the cover of the resistor compartment upward and remove three screws holding the resistor panel to the cover, thereby exposing the resistors. Unsolder the yellow-black lead from lug number two and the yellow-red lead from lug number three. Do not unsolder shunt spool leads (Fig. 9). Connect an ohmmeter on its low range between lug 2 and 3. If resistence reading is other than 20 ohms, replace the slidewire. After replacement of a slidewire, the instrument must be recalibrated.[1]

f. *Filter Circuit.* In ElectroniK potentiometers, a resistor-condensor filter circuit is provided in the detecting unit input circuit to minimize the effect of alternating current on instrument operation. The resistor is connected in series with one side of the detecting unit (Fig. 1). This capacitor must be free from "battery effects," a source of spurious emf which may cause calibration shift or motor drive on no input. If, on disconnecting one side of this capacitor, there is no appreciable change in the instrument reading, then the capacitor is free of any "battery effect."

g. *Cable Assemblies.* Interconnections of components c to f above should be checked.

h. *Standard Cell.* Where there is indication that the standard cell is defective, such as persistent calibration[1] or standardizing[1] difficulties not attributable to other sources of failure, the standard cell should be replaced.[1]

Trouble Shooting of Balancing Motor. The balancing motor (Figs. 4 and 5) is a two-phase reversible induction motor. The capacitor phase, with yellow and white leads, is connected to the line through a condenser. The other winding, having red and green leads, is connected to the amplifier output. A condenser is connected across this phase.

To check the operation of the motor, remove the motor winding screws and disengage the motor pinion from the drive gear. Connect a variable source of potential to the amplifier input terminals (green and yellow leads). Connect an output meter of 200-v range to the chassis terminal blocks where the red and green balancing motors are connected, and measure the voltage with the motor not driving. Change the variable

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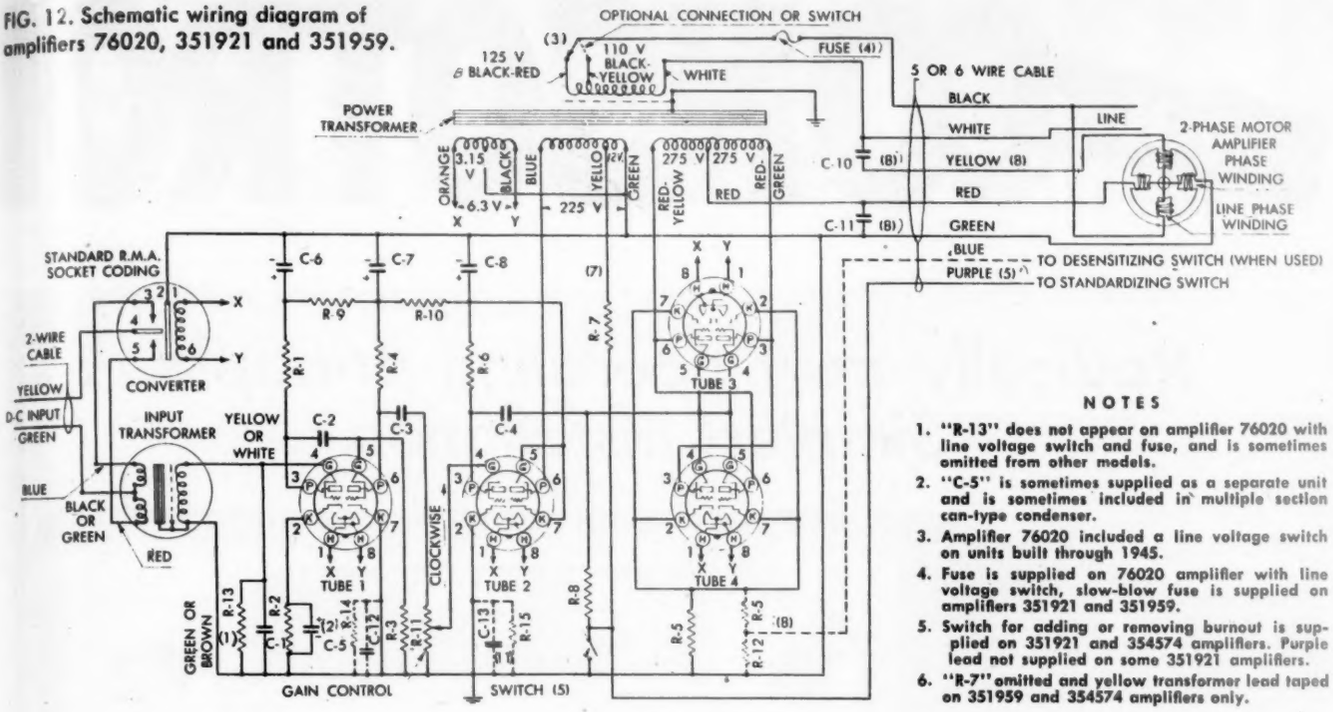
FIG. 12. Schematic wiring diagram of amplifiers 76020, 351921 and 351959.



NOTES

1. "R-13" does not appear on amplifier 76020 with line voltage switch and fuse, and is sometimes omitted from other models.
2. "C-5" is sometimes supplied as a separate unit and is sometimes included in multiple section can-type condenser.
3. Amplifier 76020 included a line voltage switch on units built through 1945.
4. Fuse is supplied on 76020 amplifier with line voltage switch, slow-blow fuse is supplied on amplifiers 351921 and 351959.
5. Switch for adding or removing burnout is supplied on 351921 and 354574 amplifiers. Purple lead not supplied on some 351921 amplifiers.
6. "R-7" omitted and yellow transformer lead taped on 351959 and 354574 amplifiers only.

TABLE 2. Voltage checks continuous balance amplifier.

Location	Measure From	Measure To	Voltage or Component Measured	Meter Scale	Correct Voltage	Recommended Corrective Action If Voltage is Incorrect
Chassis Terminal Block Amplifier Cable	Black lead	White lead	Line voltage	a-c	115 v. a-c ±10%	Check wiring to instrument, instrument power switch, cable, and fuses external to instrument.
Tube Sockets 3 or 4	Terminal 3	Terminal 6	Voltage of high voltage secondary winding	a-c	550 v. a-c ± 40 volts	Check amplifier cable, internal fuse, and line voltage switch, if any. If in order, replace power transformer. (No load conditions.)
	Terminal 3 or 6	Ground			275 v. a-c ±30 volts	
Tube Socket 5	Terminal 1	Terminal 6	Filament voltage	a-c	6.3 v. a-c ±0.4 volts	Check filament wiring and transformer (orange to black). Replace transformer, if necessary.
Tube Sockets 1, 2, 3, 4	Terminal 1	Terminal 8				
Tube Socket 2	Terminal 6	Ground	Rectifier winding voltage	a-c	225 v. a-c ± 20 volts	Replace power transformer
Transformer leads	Yellow lead	Ground	Burnout voltage	a-c	12 v. a-c ±1 volt	Replace power transformer
Electrolytic Multiple Section Round Can Filter Condenser	Notch Terminal of C-6	Ground	Rectified plate supply No. 1 Triode ½ of 7F7	d-c	115-215 v. d-c	Check C-6, R-9 and R-10 No. 2 Tube (7F7)
	Notch Terminal of C-7	Ground	Rectified plate supply No. 2 Triode 2nd ½ of 7F7	d-c	130-240 v. d-c	Check C-7 and R-10
	Notch Terminal of C-8	Ground	Rectified plate supply 1st half of 2nd 7F7	d-c	135-250 v. d-c	Check C-8
Electrolytic Condenser Tube Socket 1	Notch Terminal of C-6	Terminal 3	Plate resistance drop	d-c	75-140 v. d-c	Check R-1, R-4, R-6. Check cathode connections. Replace 7F7 tubes
Electrolytic Condenser Tube Socket 1	Notch Terminal of C-7	Terminal 6			100-200 v. d-c	
Electrolytic Condenser Tube Socket 2	Notch Terminal of C-8	Terminal 3			120-210 v. d-c	
Tube Socket 1	Terminal 2	Ground	1st cathode bias	d-c	0.7-1.3 v. d-c	Check R-2, C-5 and 1st 7F7 tube
	Terminal 5	Ground	2nd grid bias		0.3-0.8 v. d-c	Check R-3
Tube Socket 2	Terminal 4	Ground	With sensitivity control at clockwise limit, 3rd grid bias	d-c	0.4-0.8 v. d-c	Check Sensitivity control, R-11
Tube Socket 3 or 4	Terminal 2 or 7	Ground	76020-item or 351921-item amplifiers	d-c	50-60 cycle 2-5 v. d-c 25 cycle 4-10 v. d-c	Check R-5 and 7N7 tubes
			351959-item amplifier with blue amplifier lead grounded		50-60 cycle 2-5 v. d-c 25 cycle 4-10 v. d-c	Check R-5 and 7N7 tubes
			351959-item amplifier with blue amplifier lead not grounded		25-50-60 cycles 12-15 v. d-c	Check R-12 and 7N7 tubes

source to produce an increase in output voltage of the order of 5 v. The motor should start to drive, increasing to full speed as the input voltage is increased to approximately 100 v.

If the motor fails to operate satisfactorily, check the motor capacitors[1] and the resistance of the motor windings[1].

Trouble Shooting of Amplifier. Resistance checks are used on amplifiers that have been replaced for improper functioning. These checks can be made from the top of the tube sockets (Fig. 10) with the amplifier de-energized.

In checking electrolytic condensers, discharge the condenser by shorting the leads, and connect these leads to an ohmmeter. Observe polarity markings. The meter should deflect toward low resistance and then increase to the value listed in Table 1. Absence of deflection indicates an open condenser. This table also lists the approximate resistance values for power-transformer windings and the corrective action if these resistances exceed a 20 per cent tolerance.

These resistance checks are ordinarily sufficient to locate most defective parts or wiring. Other failures can be detected by running voltage checks under operating conditions.

Measured values shown in Table 2 are based on the use of a meter of 20,000 ohms per volt d-c and 1000 ohms per volt a-c. Care should be exercised when making measurements in the amplifier with the power turned on. An a-c voltage as high as 550 volts is found in the amplifier. Applying the test prods to the wrong points may result in burned-out tubes, transformers, or test meter. * *

[1] Details on calibration, standardization and other procedures outlined in this paper covering potentiometer circuits, and similar procedures on Wheatstone bridge circuits, as well as physical checking procedures for these instruments, are contained in Honeywell's Instructions Manual Number 15019M.

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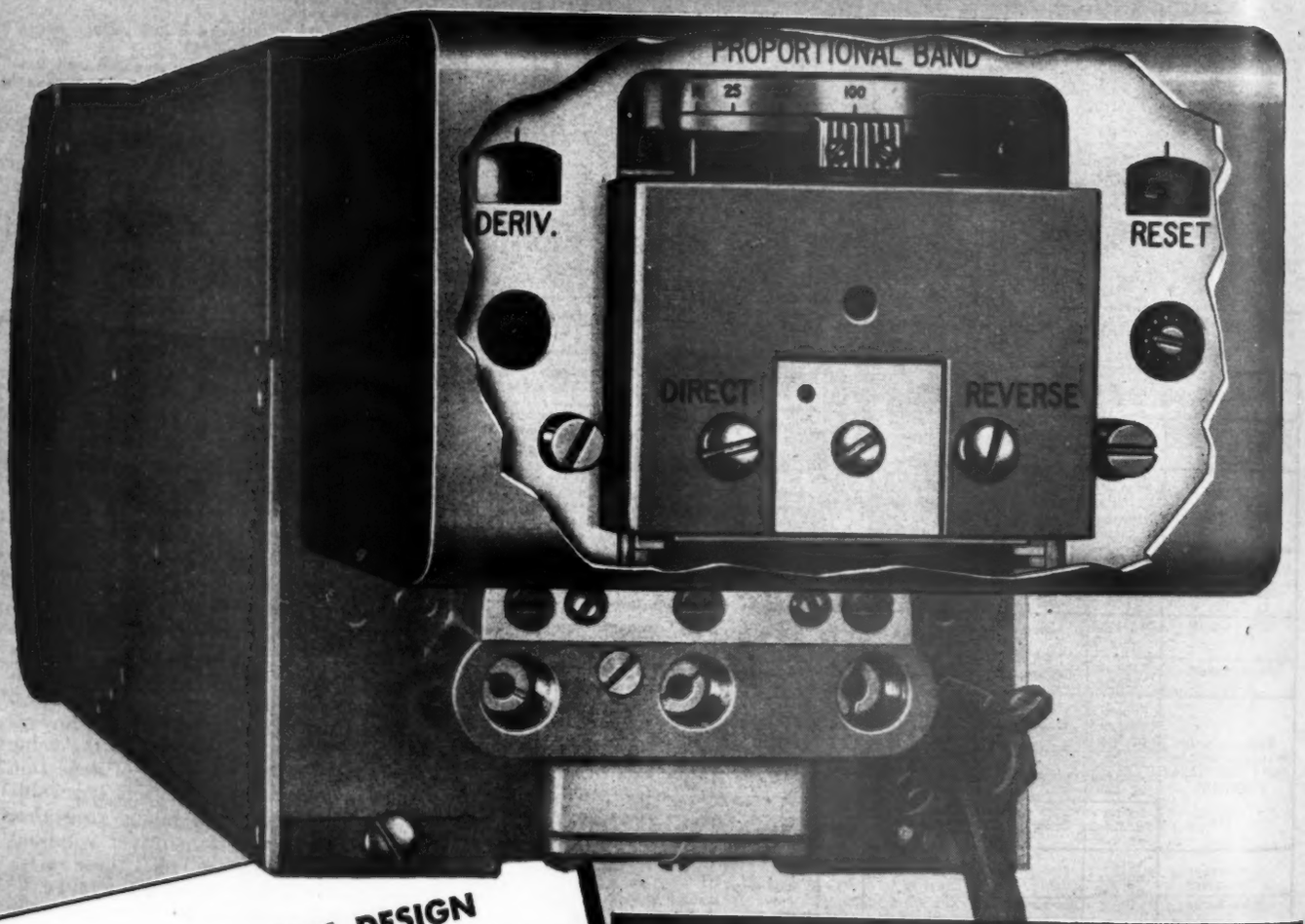

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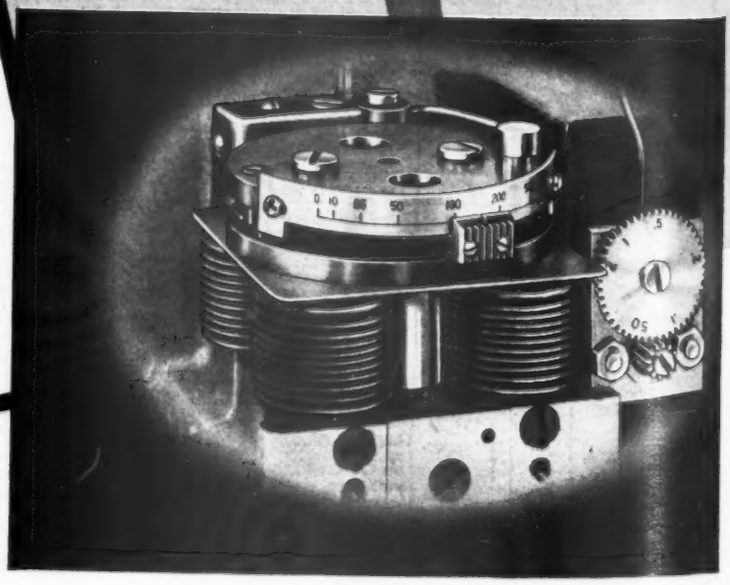
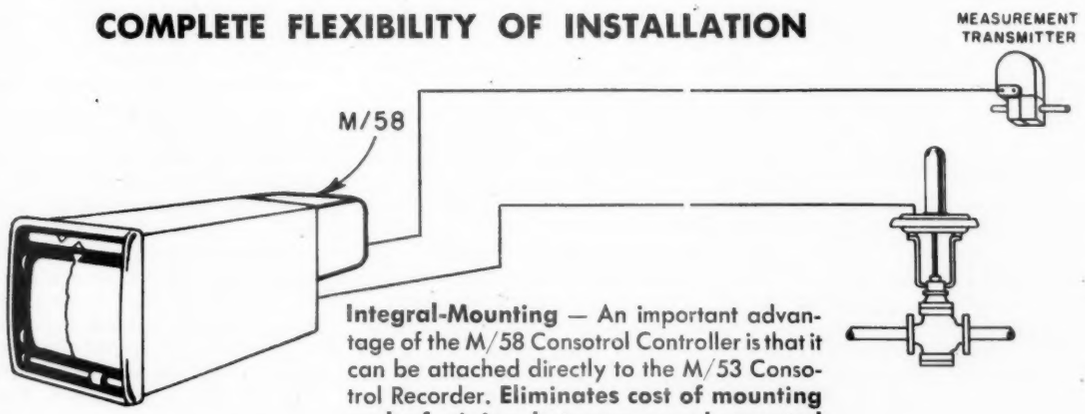
The unique "floating-disc" balancing system is shown here with dial-type reset adjustment. Derivative unit, when required, is plugged in at left of assembly. Both are readily removed or added in the field — both employ new-design adjustable restrictors providing 1000-to-1 range-ability, perfect reproducibility, and consistent rates on both increasing and decreasing air pressure. Proportional band is a lever setting, fully adjustable from 0 to infinity!

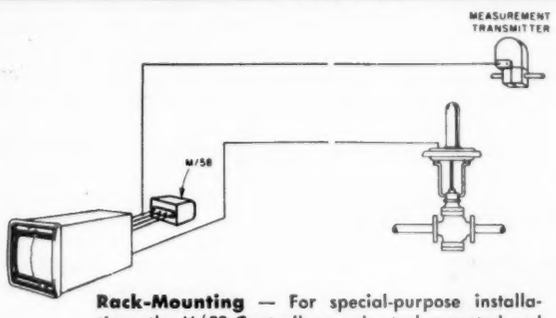


M/58 CONTROLLER

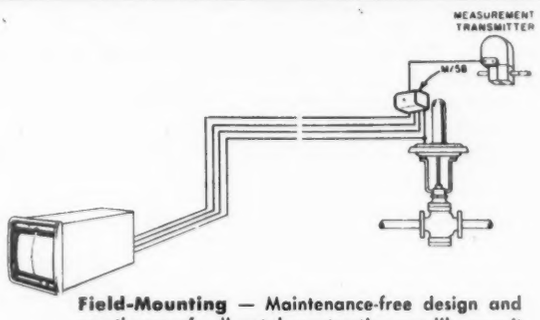
COMPLETE FLEXIBILITY OF INSTALLATION



Integral-Mounting — An important advantage of the M/58 Consotrol Controller is that it can be attached directly to the M/53 Consotrol Recorder. **Eliminates cost of mounting and of piping between panel-mounted recorder and the controller.**



Rack-Mounting — For special-purpose installations, the M/58 Controller can be rack-mounted and piped to the M/53 Consotrol Recorder or comparable unit.



Field-Mounting — Maintenance-free design and weatherproof, all-metal construction readily permit this usage when the process requires it.

Over and above its extreme compactness for graphic panel use, the new Foxboro M/58 Consotrol Controller offers unique advantages in its simplicity of design, unmatched performance, and ease of installation.

This Controller employs an exclusive, simplified balancing system in which the measurement, proportional, reset, and derivative bellows act on a single "floating-disc". With no diaphragms, only one nozzle, and only one moving part, it gives control action unrivalled in stability, sensitivity, and with positive, drift-free control point.

Installation, also, is radically simplified. The M/58 is designed to attach directly to the M/53 Consotrol Recorder (eliminating cost of piping and mounting) or, optionally, to be mounted in remote locations if required.

Write for Bulletin 463 containing full details of the M/58 Controller together with the full line of Consotrol Instruments. **The Foxboro Company, 649 Neponset Avenue, Foxboro, Massachusetts, U. S. A.** Branches in principal cities.

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Lubricating Oil Additives

Q What are the main agents, and the chemical nature of each, employed in lubricating oils to improve: (a) Pour point (b) viscosity index (c) film strength or "lubricity"?

O. C. N.

Pour Point Depressants

A A number of materials or compounds have been suggested for addition to lubricating oils to aid in reducing the pour point. These include: Soaps, such as aluminum and thorium stearates, degras, and even fatty acids of various types. Most of these compounds had some objectionable feature, such as instability, and hence the materials now employed as pour depressants largely consist of: (a) high molecular weight polymers; (b) wax naphthalene condensation products, and (c) compounds such as alkylated phenyl phthalate.

An example of the first type is a high molecular weight polymer of the esters of methacrylic acid and higher fatty alcohols such as cetyl and lauryl[2]. Such compounds are marketed as Acryloids, which may also function as VI improvers.

To produce the second class of additives, which are distributed under the name of Paraflow, chlorine, about 10 to 12 per cent, is added to paraffin wax until an increase in weight equivalent to a monochlorinated wax is obtained. This intermediate is then condensed with benzene, naphthalene, or anthracene with the aid of aluminum chloride.

The third type of pour depressants are called Santopour.

The result of the addition of a small percentage of pour point depressant is to reduce the size of the wax crystals and also decrease the amount of oil held by the wax. The action probably consists chiefly in coating the crystal surfaces by adsorption, stopping the growth of the wax crystals and displacing the layer of adsorbed oil. Such a coating also may prevent the cohesion of the crystals. The wax in a lubricating oil will crystallize even after the use of a pour depressant but the type of crystal formed will not interfere with the movement of the oil.

The effectiveness of the pour depressant will vary with the treatment the oil receives. Under a condition of slow cooling the wax crystals will be large enough so that the additive present can cover the entire surface area of such crystals. On the other hand, if the oil is chilled rapidly, extremely small wax crystals will result. The total of these small crystals will have such a large surface area that the additive is insufficient to cover all of the crystals. The crystals will therefore cohere to form a solid structure.

Also, trouble may occur upon reheating even after the oil has been cooled to the point where the wax crystals are coated with an adsorbed layer of the pour depressant. If this cold oil is heated enough to melt the wax but not the protective coating, and then recooled, the wax crystals will come out of the solution without a protective coating. These latter crystals will then cohere and the effect of the pour depressant is lost.

Bondi[1] concludes that almost any oil soluble surface active agent could be used as a pour depressant, although some might have other adverse effects upon oil properties, such as decreasing the oxidation stability.

Viscosity Index Improvers

Certain high molecular weight polymers and resins when added to lubricating oils improve the viscosity index. Rubber dissolved in oil will act in this manner, but has been found too unstable for use.

The compounds regularly employed for this purpose include: (a) an isobutylene polymer with a molecular weight of 10,000 to 15,000[7], which is marketed under the trade name Paratone; (b) polymers of esters of methacrylic acid and higher fatty alcohols[2], which are sold under the name Acryloids, and (c) alkyl styrene polymers, which have been given the name Santodex.

For such polymers to be capable of improving the VI of a lubricating oil, they must undergo a change in solubility in the oil between the temperatures at which the slope of the temperature-viscosity points are determined, that is between 100 F and 210 F. The polymer can exist in either a true solution or as a colloidal suspension in the oil. For polymers of this nature, the effect upon viscosity is greatest when in solution. Therefore, when the blend of the oil and the polymer is heated to 210 F and the polymer goes into true solution, the viscosity of the mixture will be higher

New Technical Forum Member

Gerald Fisher

Gerald Fisher, manager of lubricants and process products department of General Petroleum Corporation, like a large number of other oil men, has spent a good long period in Oklahoma. In fact he began his grammar and high school education periods in Enid, Oklahoma, after having been born in Scottsburg, Indiana. As a chemical engineering graduate of Oklahoma University, (1920), he worked as Colorado Fuel and Iron chemist for three years, joining General Petroleum in 1923. He climbed to supervisor, chief chemist, (Vernon Control Laboratory), up to supervisor of chemical and control laboratories, in 1935. Socony-Vacuum Oil Company, Inc., borrowed him, 1941-43, to head its Washington office. He went back to General Petroleum as chemical and lubricants laboratory supervisor, then to his present managership in 1944. His present duties lie in the development and manufacture of specialized petroleum products and lubricants.

He holds active memberships in the American Chemical Society, Society of Automotive Engineers, Army Ordnance Association, Alpha Chi Sigma, and the Petroleum Club of Los Angeles. He lives in Chapman Woods near Pasadena, with wife Gladys, nee Lundblade. His hobbies are gardening, fishing, and color movies.

Fisher will answer questions for the Forum on the subjects of lubricating oils, greases, and the manufacture of these and related products in the lubrication field.

than it would be otherwise. On the other hand, as at 100 F the polymer is present in a colloidal form, it has little influence upon the viscosity of the mixture.

Film Strength and "Lubricity"

The two terms above are not synonymous. In fact, lubricity is defined as smoothness or slipperiness. This then may be what some people term "oiliness". At the minute there does not seem to be a better definition of "oiliness" than that proposed by Herschel[5]. It is as follows: "Oiliness is that property that causes two lubricants to give different coefficients of friction, when their viscosities at the film temperature and all other experimental conditions are the same."

Even after a definition is decided upon there is the question of a laboratory test that will evaluate this property of a lubricant. From a practical standpoint Georgi[4] states, "No authoritative data are published that indicate that motor oils containing 'oiliness' additives increase power output or reduce fuel consumption, or that any significant reduction in engine wear occurs after extended operation."

Addition of compounds that will orient themselves at metal surfaces may be a contributing factor toward increased "oiliness". Fatty oils are valuable in this connection and even better are certain fatty acids. As such compounds may act on copper-lead or cadmium bearing metals, other materials have been advocated for this purpose. These include: butyl stearate, methyl esters of oxidized wax acids, methyl ester of chlorostearic acid, diesters, fatty alcohols, and nitriles. By X-ray diffraction studies, certain workers[3] confirmed the fact that some such compounds produce an orientated film on metal surfaces.

Although the above additives act by physical adsorption, "Film Strength Additives" react with the metal surfaces due to the heat of friction and as a consequence form a tough chemical coating which prevents intimate contact of two metal surfaces.

Most film strength additives, or as they are generally known EP (extreme pressure) additives, contain as an active ingredient either chlorine, phosphorus, or sulfur compounds. These chemical elements are in such form that under high pressures between metal surfaces they react with the metal to produce chlorides, sulfides, or perhaps phosphates, which will either sustain the load or prevent welding of the two metal surfaces together. Selenium and tellurium compounds act in a similar manner to sulfur compounds. Likewise, lead soaps may be used with sulfur compounds resulting in the formation of lead sulfide when subjected to high pressures.

EP lubricants may be of the mild or powerful type, the former being capable of withstanding a lower load than the latter. The sulfur may be present in a so-called "active" or "inactive" form. The inactive type of sulfur compounds will not discolor copper or brass at temperatures below 300 F, while the active type will stain such metals at low temperatures. Where bronze parts come in contact with an EP lubricant, the inactive type of sulfur compound should be specified.

As chlorides or sulfides of metals may be formed when an EP additive is present there is some possibility of abrasion. From this standpoint such lubricants would not be desirable for anti-friction bearings.

The first EP gear lubricants were oils from the Smackover field in Arkansas, which contained considerable natural sulfur compounds. Later lead soaps were added to such oils to increase the load carrying capacity. Still later, sulfurized fatty materials were used as a means of introducing sulfur. In some cases such fatty materials were treated with sulfur-chloride so that two active EP elements were introduced. Next mixtures of chlorinated paraffin and organic compounds were employed. Now many EP additives also contain organic phosphorus compounds.

Tricresyl phosphate in concentrations of 0.5 to 3 per cent was used as a film strengthening agent by Hunt[6]. Other EP agents include chloro-di-phenylether, methyl dichloro stearate, and tritolyl phosphate. Some compounders have used dibenzyl disulfide and xanthate compounds. The patent literature covering EP additives is voluminous. For illustration, one summary[8] covers about 200 lubricating additives for the years 1938-39 and most of these are patents for EP type additives.

In this connection wear prevention agents might be mentioned, since Beeck *et al*[1a] claim that wear-preventing agents and EP agents can be distinguished from each other. According to these workers, wear-prevention additives produce their effects by chemical polishing action, causing the load to be distributed over a large surface so that local temperatures and pressures are reduced. Addition of 1.5 per cent of various compounds to a white oil and tests on a four-ball apparatus showed that tricresyl phosphate reduced wear to a greater extent than either dibenzyl disulfide, oleic acid, or stearone. Combinations of additives gave a still lower wear, 1.5 per cent of triphenyl phosphine and 1 per cent of tristearin or 1.5 per cent of triphenyl arsine and 1 per cent of mesityl heptadecyl ketone being the best combinations employed.

C. J. B. & R. R. M.

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Lubricant Additives

Q What are the main classes of additive compounds employed in lubricants to improve (a) corrosion resistance; (b) varnish deposition; (c) sludging; (d) acidity; (e) detergency? What are considered the best individual compounds in each class, for each purpose.—M. V.

A (a) Corrosion Resistance. Two types of compounds are generally employed as additives to combat corrosion.

(1) Organic compounds containing sulfur and/or phosphorus act in two ways. They prevent corrosion by reacting with bearing surfaces to form a very thin film of sulfides or phosphates. These additives also function by combining with the very small particles of bearing metals present in used lubricating oils and by their poisoning action render these metal particles essentially non-reactive with the oil.

(2) Conversion of corrosive acidic substances formed in an oil in service are rendered harmless or non-corrosive by reaction with alkaline compounds that combine with these acidic substances. Compounds generally used are amines and metallo-phenol compounds.

In addition to the above, certain additives are used for rust prevention, which is a specialized case of corrosion prevention. Compounds generally used for this type of service are polar compounds and metal sulfonates. These compounds function by adhering tightly to the metal surface and preventing the rusting action of water.

(b) Varnish Deposition.

(c) Sludging.

(d) Acidity.

These subjects have been grouped as in the process of oxidation the chemical changes that take place result in the formation of peroxides and organic acids. Both of these products attack and damage metal surfaces and promote deterioration of the lubricating oil. The peroxides act as active catalysts in promoting further oxidation of the oil. Acids formed may enter into polymerization and condensation reactions to form large molecules that eventually become insoluble in the oil and settle out as sludge or are deposited as lacquer. Under high temperature conditions existing in certain areas of internal combustion engines, further breakdown of this substance results in carbon formation.

Additives that combat oxidation are usually organic chemical compounds containing phosphorus, sulfur, or aromatic rings with attached phenolic or amine groups.

(e) Detergency.

Additives employed for this purpose usually consist of:

(1) Alkaline earth metal salts (calcium, barium, magnesium) of sulfonic acids.

(2) Metal salts of wax-substituted phenol derivatives.

(3) Alkaline earth metal salts of the alkyl phenol sulfides.

Gerald Fisher.

NEW ANALYTICAL METHODS

A Total Vaporization Method†

Determination of equivalent vapor volumes of pentanes plus fractions

S. T. PRESTON*

For purposes of accounting and plant material balances, natural gasolines are generally resolved into the light hydrocarbons and a liquid residue. This residue consists of the hydrocarbons heavier than normal butane and is a mixture of normal paraffins, isoparaffins, aromatics, and cycloparaffins (naphthenes). The frequent necessity of interrelating a liquid basis and a vapor basis requires a knowledge of the vapor equivalents of these pentanes(+) fractions. The procedures available (for example, CNGA Bulletin TS-411) for the determination of the vapor equivalent generally require two or more hours per sample. This expense of time has led to the frequent use of correlations such as the one published by D. B. Johns.[2] See Fig. 1.

It was our hope at first that some one other variable could be introduced into the correlation to obtain increased accuracy. By reference to Table 1 and Fig. 2, it is seen that vapor equivalent cannot be correlated accurately with gravity unless the residue is composed of a single known type of hydrocarbon. Previous studies have indicated that the pentanes(+) residue may be composed of the four types of hydrocarbons listed previously. In order to completely define such a mixture, it is necessary to use several measured properties. Because several such measured properties are required, the value of indirect methods of obtaining vapor equivalent is considerably diminished.

TABLE 1. Gravity and vapor equivalent data for Fig. 2*.

Normal paraffins	Gravity °API	Vapor eq.[3]
Pentane	92.7	27.62
Hexane	81.6	24.32
Heptane	74.1	21.68
Octane	68.7	19.53
Nonane	64.6	17.76
Isoparaffins[2]		
Pentane	95.0	27.33
Hexane	83.6	24.10
Heptane	75.7	21.52
Octane	70.1	19.40
Nonane	65.7	17.66
Cycloparaffins		
Cyclopentane	57.0	33.78
Cyclohexane	49.1	29.38
Methyl cyclopentane	56.3	28.26
Methyl cyclohexane	51.3	24.88
Aromatics		
Benzene	28.5	35.75
Toluene	30.8	29.83
p-xylene	31.9	25.74

[1] Values from ASTM Special Technical Publication No. 109
[2] 2-Methyl paraffins
[3] Pressure base = 14.73 psia

Apparatus and Procedure

As a result of the foregoing considerations, it was decided that a simple direct measurement of vapor equivalent would be desirable. A method was developed that is essentially a simplification of that developed by Young and Taylor.[5] The method consists of introducing a measured quantity of liquid into an evacuated vessel and measuring the resultant pressure increase. The apparatus is shown in Fig. 3. The four essential parts of the apparatus are: Liquid measuring pipette, sample introduction glass valve, multiplying manometer, and the vaporization bulb.

Liquid Measuring Pipette. There are several methods available for the measurement of small liquid samples with the required accuracy. For very precise determinations, the microburette described by R. Gilmont,[1] and available from The Emil Greiner Company, is recommended. For routine determinations on pentanes(+) fractions from natural gasolines, a pipette may be constructed for constant volume delivery. This pipette is a 15-in. length of 1 mm ID capillary tubing with one end ground to a point. The tip should be constricted with a torch to about 0.1 mm ID prior to grinding. A single calibra-

†Presented before California Natural Gasoline Association, September 6, 1951.

*California Research Corporation, presently assistant professor of petroleum engineering at the University of Texas.

FIG. 1. Vapor equivalent-gravity for pentanes (+) fractions from typical California gasolines.

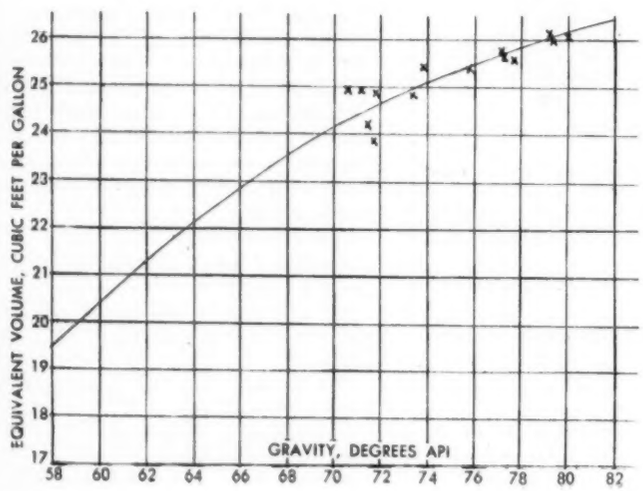
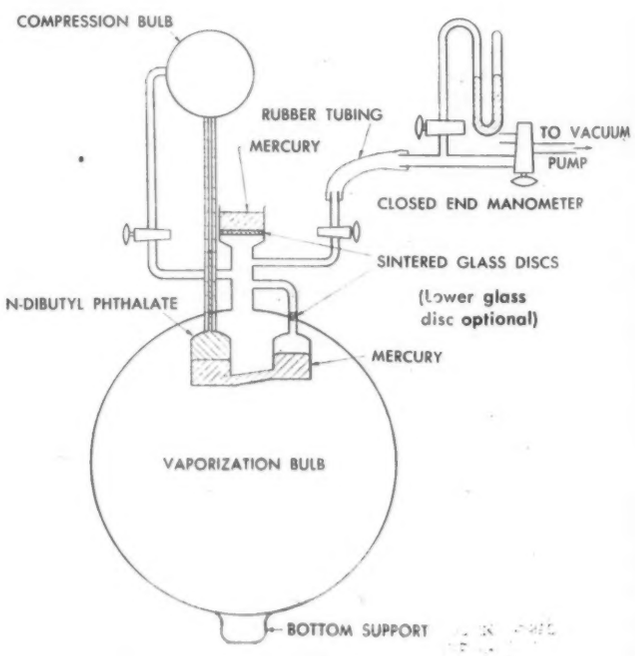


FIG. 3. Vapor equivalent apparatus.



tion mark is scratched on the pipette about 5 in. from the tip. In order to make a sample addition, the sample is added to a small diameter test tube containing about 1½ in. of mercury. The tip of the pipette is placed into the mercury and about one inch of mercury is drawn into the pipette. The tip is then raised into the sample layer and sample is drawn into the pipette to a level several inches above the calibration mark. After removing the pipette from the test tube, the level of sample is lowered slowly until the sample-mercury interface is at the calibration mark. The sample is then ready for introduction through the sintered glass disc.

Sample Introduction Glass Valve. The method of introducing liquid samples through sintered glass discs has been described by several authors.[3,5] Briefly, this method is dependent on the fact that a sintered glass disc (porosity F) is porous to gases and liquids in general, but nonporous to mercury. A sintered glass disc covered with a layer of mercury thus forms a vacuum seal through which other liquids may be introduced. Sample introduction is accomplished by touching the tip of the pipette to the disc. The mercury slug in the pipette serves the dual purpose of sweeping the sample from the pipette and terminating the flow from the pipette. As a differential pressure of 15 psi will cause mercury to enter the pores of a sintered disc, thereby reducing its porosity to other liquids, the mercury layer should be less than one inch deep. The capillary depression of the mercury within the pipette is about 10 mm. The mercury layer on the disc must, therefore, be deeper than 10 mm in order to leave a portion of the mercury in the pipette as a seal to prevent the entrance of air.

Multiplying Manometer. The manometer developed by Young and Taylor[4] is not suitable for use in other than research laboratories. The extremely fragile nature of this manometer made it desirable to resort to a simpler method of measuring pressure. The multiplying manometer shown in Fig. 3 was developed to give the required accuracy (considerably less than the Young and Taylor manometer) without being unduly fragile. Dibutyl phthalate was used as the manometric fluid because of its low vapor pressure and density. The large solubility of vapors in the dibutyl phthalate required the use of mercury as a pressure transmitting fluid. A multiplication factor of 10 was found to be adequate for routine determinations, although this manometer may be constructed to give considerably greater amplification of pressure readings. The manometer is constructed as shown in Fig. 3 with two pots about 30 mm ID and a capillary leg of 3 mm ID. Reducing the internal diameter of the capillary leg increases the amplification of the manometer, but also introduces an undesirable time lag.

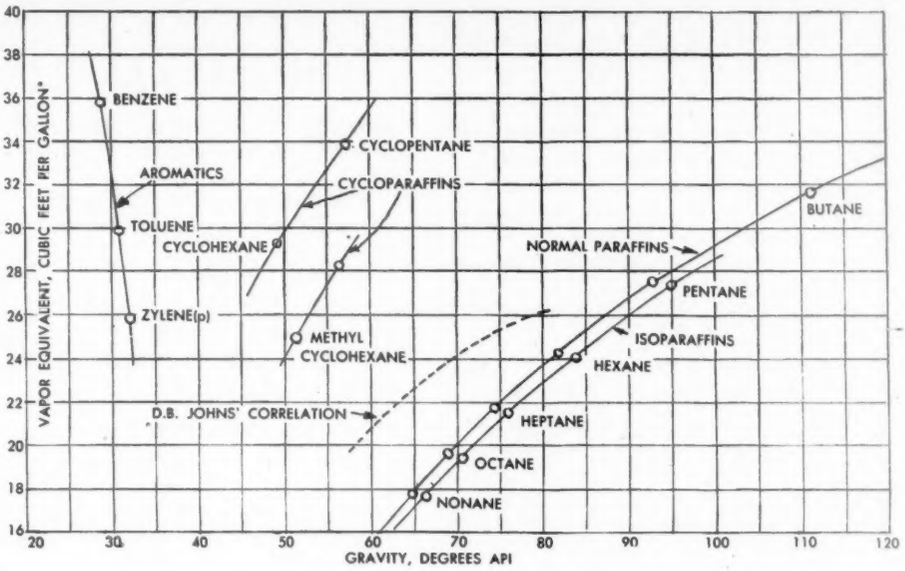


FIG. 2. Gravity-vapor equivalent correlation.

Greater multiplication can be obtained by inclining the capillary leg of this manometer; however, drainage of the butyl phthalate then becomes difficult. The sintered glass disc between the manometer and the vaporization bulb will prevent the manometric fluids from entering the vaporization bulb, provided the disc is located so that the mercury will contact the disc before the butyl phthalate breaks through into the right hand pot.

The compression bulb on top of the manometer serves to reduce (to a negligible quantity) the error caused by compression of the gas above the butyl phthalate. Calculations show that, with a compression bulb volume of 300 cc, the pressure within this bulb must be reduced to 1.0 mm Hg if the error is to be kept down to the uncertainty in manometer reading (0.1 mm out of 40.0 mm). The compression bulb may be only 30 ml in size if the initial pressure within the bulb is reduced to 0.1 mm Hg.

Vaporization Bulb. Because the size of the vaporization bulb is directly related to both sample size and pressure increase, it is seen that if the bulb is made small the sample must be correspondingly small or the pressure rise becomes large. In order to vaporize components as heavy as nonane and decane, it is essential to limit the pressure rise to the minimum that will give an acceptable accuracy of pressure reading. The apparatus herein was designed for a pressure rise of 4 mm of Hg. With this pressure limit, a vaporization bulb of three liters require a sample of about 0.075 ml. The size of the vaporization bulb may be decreased if the smaller sample required can be measured accurately. The vaporization bulb must be mounted submerged in a water bath having the water level at or above the sintered disc.

Procedure and Calculations

The vapor equivalent used in California is defined as the cubic feet of vapor (measured at 60F and 14.73 psia) per gallon of liquid (measured at 60 F). Mathematically,

$$\text{Vapor equivalent} = \frac{V \times \left(\frac{520}{T}\right) \times \left(\frac{\triangle P}{761.76}\right) \times \left(\frac{1}{28.316}\right)}{c \times b \times \left(\frac{1}{3785.3}\right)} \quad \ldots \quad (1)$$

Where

V = volume in liters of vaporization bulb
T = temperature of vapor (water bath) °F
△P = pressure rise, mm of Hg
c = volume of sample, ml (at temperature of measurement)
b = d_t/d_{60}, ratio of sample density at temperature of measurement to density at 60 F.

The pressure rise, △P, is related to the difference in manometer readings, △M, by a constant factor depending on the dimensions of the particular manometer. The sample volume, c, and vaporization bulb volume, V, are both essentially constant, permitting the above relation to be rewritten:

$$\text{Vapor equivalent} = K\left(\frac{V}{c}\right)\left(\frac{\triangle P}{bT}\right) = K_1\left(\frac{\triangle M}{bT}\right) \quad \ldots \quad (2)$$

$$\text{where } K = \frac{520}{761.76} \times \frac{3785.3}{28.316} = 91.255$$

The procedure for determining the

vapor equivalent of a sample involves first the evaluation of the constant

TABLE 2. Vapor equivalent determination on known compounds by total vaporization method.

	Determined vapor equivalents			Calculated V.E. for pure compounds
	1st run	2nd run	3rd run	
Normal heptane..	21.48	21.55	21.55	21.68
Normal pentane..	27.93	27.93	—	27.62
2-methly pentane	24.33	24.54	24.40	24.10
Cyclohexane.....	29.16	29.16	—	29.38
Carbon tetrachloride...	32.45	32.45	—	32.73

K_1. This is done by introducing into the apparatus the constant volume, c, of a known pure compound and observing $\triangle M$ and T. From the known vapor equivalent of this compound and its liquid expansion coefficient, the calibration constant K_1 can be computed. The determination of an unknown sample is then reduced to observing $\triangle M$ and T when the volume, c, of sample is introduced. Values of b may not be obtained from the Tag Manual for Inspectors of Petroleum. It may be noted that this method does not require determination of the absolute volume delivered by the pipette, the volume of the vaporization bulb, or the multiplication factor of the manometer.

The relation between molecular weight and vapor equivalent is frequently required. With the addition of a sample density measurement (or reasonable assumption of density), the molecular weight of the unknown may be computed. From Boyle's law relations, we obtain:

$$\text{Molecular weight} = 34.66\left(\frac{c}{V}\right)\left(\frac{Td_t}{\triangle P}\right) \quad . \quad . \quad (3)$$

where d_t = density of sample at temperature of measurement (gm per ml).

Eliminating $\triangle P$ from Equations 2 and 3, and solving for molecular weight:

$$\text{Molecular weight} = \frac{3163 \times d_{60}}{\text{Vapor Equivalent}} \quad . \quad . \quad (4)$$

where d_{60} = liquid density of sample at 60 F, gm per ml.

Test Data

Tests made on known compounds gave the results tabulated in Table 2. Variations were well within the accuracy required and indicated good reproducibility. Test results obtained on pentanes (+) fractions from gasolines agreed with CNGA correlation values generally in the range of high gravity, but differed considerably in the low gravity range. These results are tabulated in Table 3.

TABLE 3. Comparison between correlation and determined vapor equivalent values of pentanes (+) fractions.

Sample	Correlation vapor equivalent value*	Determined vapor equivalent 1st run	Determined vapor equivalent 2nd run
A.....	26.22	25.72	25.72
B.....	26.02	26.00	25.73
C.....	25.82	25.79	25.65
D.....	25.15	25.24	25.39
E.....	24.58	24.61	24.53
F.....	23.41	25.12	25.08
G.....	23.10	24.89	24.89
H.....	22.60	24.28	24.28
I.....	22.51	23.86	23.86
J.....	21.28	24.52	24.19

* CNGA Bulletin TS-411, Fig. 14

Vapor equivalents by this method may be run as a routine on C_5(+) fractions from wet gases after cutting out n-butane the C_5(+) sample is frozen into a small calibrated tube and warmed to 60 F for liquid volume determination. Mercury is placed in the tube, and the sample pipetted into the vapor equivalent apparatus.

Limitations of Method

The method may be used on any liquid (i.e. in liquid state at room temperature and atmospheric pressure) that will vaporize completely at 4 mm Hg abs at the temperature of the bath. By increasing the bath temperature to 150 F, the upper range of the method may be extended to correspond to a molecular weight slightly above 140.

Acknowledgment

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* * *

Iodometric Method for T. E. L. in Gasoline

P 228.

O. M. DUNCAN*

THIS method describes a volumetric procedure that eliminates the use of the more time consuming gravimetric method and uses the precise iodine titration.

The apparatus for extraction is that described by the ASTM.

Procedure

Fill the thistle tube of the extraction apparatus to the 50 ml mark with concentrated HCl and allow to drain into the boiling section. Start water circulation through the condenser and turn on the heat, nearly full until boiling starts then reduce until there is almost a steady stream of condensate dripping off the condenser. Reflux for 25-30 minutes. Shut off heat, allow to cool a few minutes and drain off acid layer into a clean 600 ml beaker. Again reflux the sample, this time for 10-15 minutes with about 50 ml of distilled water. Add water layer to previously withdrawn acid layer.

Add several ml of concentrated HNO_3 to the beaker and evaporate to dryness. Cool and add a few more ml of HNO_3 and again evaporate to dryness. Repeat until organic matter is destroyed as shown by the presence of white lead nitrate. Bake free of nitric acid on the hot plate but do not heat enough to volatilize the lead. Cool. Add about 200 ml distilled water and 3-5 drops glacial acetic acid. Bring to boiling and precipitate the lead by slowly adding to the boiling solution from a pipette 5.0 ml of 0.5 N $K_2Cr_2O_7$. Continue boiling until the precipitate becomes orange colored and will settle readily. Cool somewhat and filter through a No. 42 Whatman paper. Wash beaker one and paper once with distilled water.

Titrate the filtrate in the same way as the blank determination is made to standardize the thiosulfate solution.

Thiosulfate Solution

Dissolve about 35 grams of $Na_2S_2O_3.5H_2O$ in enough boiled distilled water to make about one liter of solution. This is standardized as follows: Into a 500 ml erlenmeyer flask containing about 200 ml water and a few drops of glacial acetic acid, pipette slowly 5.0 ml of 0.5 N $K_2Cr_2O_7$ solution. Add about 1 gram of KI and 10 ml concentrated HCl and titrate immediately with the thiosulfate solution adding starch solution near the endpoint. *This blank determination should be made daily.*

Calculations

$(B-S) \times 5/B \times 1.24 =$ ml T.E.L. per gallon.

where

B = ml thiosulfate solution for blank and

S = ml thiosulfate solution for sample.

*Indiana Farm Bureau Cooperative Association, Inc.

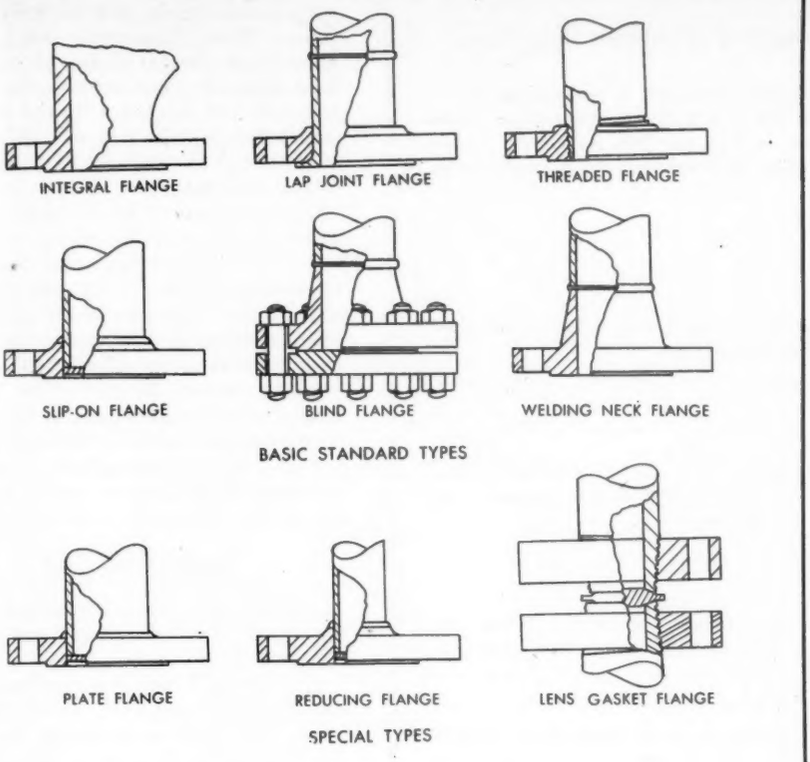


FIG. 1. Flange types.

GASOLINE PLANT DESIGN

PART 7. Fields of application of various type flanges and service limitations of each type are presented

O. L. LEWIS*

THE modern gasoline plant uses many flanged joints, and the different types of standard flanges each serve a purpose.

The first use of pipe flanges can be traced back to the 16th Century. At that time, rough flanges were first cast on pit cast-iron pipe. The flanges were not finished and had to be used with a thick soft gasket. Of course, the joint would hold only very low pressures. Machined flange facings came into use only about 100 years ago. Then the gasket thickness was reduced and the joints would hold higher pressures.

Machinery for threading pipe and tapping flanges was developed about 1860. It was only then that flanges could be attached to pipe by any means other than casting. In 1900, the van-stone lap-joint type flange was developed. The flange then could be slipped on the pipe and the end of the pipe upset to form a shoulder. At that time, van-stoned piping was expensive, so there was a definite incentive to develop a flange that could be installed on the job without special tools. By 1928, welding was well enough advanced to make the welding-neck and slip-on flanges practical.

About 1937, higher pressures required high tensile pipe, and welding was difficult. Then the variations of the lens-type flange joint were developed. The flanges we use today are all variations of the types developed up to 1939. The main changes since that time are in flange facings and gasket types and materials. At present, there are seven basic flange types. Variations of these types are used depending upon the service. (See Fig. 1.)

*C. F. Braun and Company.

EXCLUSIVE

The Integral Flange

The integral flange is cast or forged as a part of the valve, fitting, or equipment. Some manufacturers of valves and special fittings use welding neck flanges instead of integral cast flanges to make up their product. This method of fabrication, however, is usually based upon the machine set-up of the manufacturer and not upon any inherent advantage or disadvantage of the flange type.

The integral flange provides a satisfactory connection to manufactured fittings and equipment. Shorter face-to-face dimensions are possible, and it is usually more economical to use on manufactured items. It is normally a stronger connection than a welded assembly, because of the heavier neck thickness.

The Lap-Joint Flange

This type flange, commonly known as the van-stone type, has two main advantages over others that can be attached in the field. The most obvious advantage is that the flange can be rotated on the pipe. This feature simplifies line up of the bolt holes at odd angles. Where piping is subject to some mis-alignment or is installed at an odd angle, this type flange should definitely be considered. The other main advantage is that pipe-to-pipe contact is obtained. This feature may be desirable in corrosive service. The pipe and van-stone stubs, of course, must be alloy, but the actual flanges may be carbon-steel as they are not in contact with the corrosive medium. This feature of the lap-joint often proves quite economical.

Disadvantages of the lap-joint are: (1) Two pieces to warehouse and handle, against one for other flange types; (2) higher installed cost, and (3) resistance to torque is entirely dependent upon friction between the contact surfaces. Any slippage will tend to cause the joint to leak.

Threaded Flanges

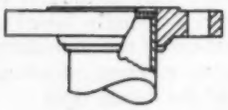
This was the first type of attached flange developed. At the present time, it is used primarily in two applications. (1) For repair work in hazardous areas where welding is not permitted, and (2) in high-pressure piping, where high tensile strength pipe is not suitable for welding. This is a screwed joint and subject to leaks, so it is not ordinarily used when conditions permit the use of any other type flange.

Screwed flanges may be installed and seal-welded. There is some advantage to this practice, but it is not entirely satisfactory. A light seal-weld is not heavy enough to hold pressure leaking by the threads. If the seal-welds are made heavy enough to hold the pressure there is another problem. The heavier weld will tend to loosen the threads. Then the joint is only the equivalent of a slipon-flange with only the hub-weld. We all agree that slipon-flanges need

FIG. 2. Normal application for and limitations of standard flange types.

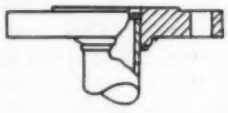
SCREWED FLANGE

Use only where flanged connection is required on 1½-in. and smaller within 150 lb and 300 lb ASA ratings. Should be seal welded for services over 500 psi or 600 F. Also applicable where pipe or flange material not suitable for welding.



SLIP-ON

Use only within 150 lb and 300 lb ASA ratings where space does not permit butt welding type.



REDUCING

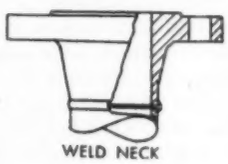
Use only where change in line size is necessary in minimum space, line not subject to high external stress and flow characteristic not critical.

BLIND

Use for end closure for line where cleanout or future connection anticipated. Much more expensive than weld cap.

LAP JOINT

Use where rotational alignment of bolt holes on fixed flange would be difficult and pipe is fixed to prevent excessive bending stress in joint. Should not be used on large or thin walled pipe.



WELD NECK

Preferred for all severe service conditions up through ASA 2500 lb standard where pressure, temperature, shock, vibration or external stress is high. Generally the most economical installed cost.

two welds, so this back-welded arrangement cannot be considered a satisfactory joint.

The Blind-Flange

The blind-flange and companion-flange are more expensive than a welding cap. It is not used for an end closure except when future extension or access is required. It is also used to close off unused nozzles in apparatus and as a cover for handholes and manways where required.

The Slipon-Flange

This is one of the two most popular flange types. The slipon-flange in 150-lb and 300-lb classes is acceptable to the ASA code. The main advantage of this flange type are: (1) easier alignment for welding; (2) lighter weight, and (3) shorter face-to-face makeup dimensions on fabricated assemblies.

There are disadvantages too. The major ones are: (1) Two fillet-welds instead of one butt-weld. Generally, it is easier to ascertain that a butt-weld is sound, than it is to ascertain that a fillet-weld is sound. (2) Produces higher bending stresses in the pipewall. (3) Lower fatigue life of the joint. Fatigue failure will usually occur at the base of the fillet-weld in about half the time required for failure of the weld at a butt-welded flange. (4) Possible warping in the flange face, due to the heat of welding and unequal cooling. This factor is more critical in large size flanges.

Reducing Flanges

Reducing flanges are made in both slipon and butt-weld types. The slipon is the most common and the butt-weld reducing flange is definitely a special. The slipon type is subject to the same advantages and disadvantages pointed out above. The moment on the fillet-weld is increased as the size of pipe is decreased relative to the flange diameter. This factor may lead to high stress concentration in the pipe adjacent to the weld. The abrupt reduction in line size causes turbulence and increased pressure-drop. Reducing flanges carry the same pressure temperature ratings as slipon flanges, but they should be used with caution for the reasons mentioned.

Welding-Neck Flanges

The ASA Code rates welding-neck flanges from 150 lb through 2500 lb classes. The size range is ½-in. through 24-in. At the present time, the welding-neck flange is used more than all the other types. We hear that the welding-neck is harder to line up for welding than a slipon. Apparently this factor is not critical. Several studies of costs have been made. In each instance, the overall installed cost was lower for the welding-neck than for the slipon. This is true even though the welding-neck flange itself is more expensive.

The butt-weld is better suited to high bending and cyclic loads than the fillet-weld. Stress in welding-neck flanges is approximately 20 per cent less than any of the other types with identical loading. One manufacturer has made tests indicating that the controlling stress in welding-neck flanges is only about 50 per cent of that in slipon flanges. The actual figure varies with flange size and rating.

Fig. 2 shows the suggested application and limitations of standard flange types.

Special Flanges

Several variations of standard flange types have been developed for special applications.

One special flange type is a basic butt-welding flange using a C-clamp arrangement. This arrangement puts the bolts in compression instead of in tension. This switch allows higher bolt loading. And that is a definite advantage in large diameter flanges at relatively high pressures.

Another special is particularly adapted to pressures above the ASA 2500-lb rating. This joint consists of a high-tensile material flange screwed on the pipe. The pipe ends are machined to a spherical shape and project through the flanges. A steel plate gasket is used between the pipe ends. Bolting through the flanges forces the pipe ends into the softer gasket plate to make the joint. The gasket plate surface is machined to a different curvature than the pipe end. This shape combination reduces seating area and allows for a little mis-alignment. As the flanges are not attached by welding, the pipe and flanges can be of high tensile material not suitable for welding. This joint is widely used for extremely high pressures in chemical plant and coal hydrogenation piping.

Large O-D Flanges

The ASA standard for steel flanges only applies through 24-in. size. In low-pressure gasoline plant work, larger flanges are frequently required. Up through 24-in. size, the bolting of the 150-lb steel flange matches the 125-lb cast-iron flange standard. This is not true of sizes larger than 24 in. Steel flanges can be bought to the 125-lb standard in larger sizes, but the thickness is greater than required for most services. The Taylor Forge Company makes a large o-d 150-lb steel flange, but the bolting does not match 125-lb valves or equipment flanges. The Tube-Turn Company manufacture a light-weight 125-lb steel flange. The bolting does match equipment flanges, and the

flange is much more economical than the standard 125-lb flange. This lightweight flange is rated at 100-lb at or near air temperature. The rating is on the basis of a non-metallic full-face gasket.

Actually, the bolting is the limiting factor for this flange. The design is based upon carbon steel, ASTM A-261 bolts. If ASTM A-96 Grade C or ASTM A-193 Grade B-7 bolts are used, the flange rating is increased. With this alloy bolting, the flanges are recommended at 100 lb up to 400 F for liquid steam, or gas service.

This flange with alloy bolting and full-face service sheet gaskets, has a wide field of application in low-pressure compressor lines. The pressure rating will usually limit its use to incoming gas lines and to first-stage compressor suction and discharge piping.

Flange Materials

Temperatures are not as much a factor in gasoline plant piping as in refinery work. The primary factor in the choice of gasoline plant flange material is allowable stress under design conditions. The ASTM specifications for A-181 and A-105 flange materials cover most gasoline plant services. Both ASTM A-181 and A-105 are available in Grades 1 and 2. Grade 1 material is specified to have minimum tensile strength of 60,000 psi. Allowable design-stress is 15,000 psi. Grade 2 material has a minimum tensile strength of 70,000 and allowable design-stress is 17,500 psi.

Both grades are limited to 0.35 per cent carbon. The higher tensile strength of the Grade 2 material may be obtained by adding up to 0.30 per cent silicon. Grade 2 physical specifications are much more rigid than Grade 1. The Grade 2 material has only 81 per cent of the allowable elongation, and about 68.5 per cent of the reduction in area allowed for Grade 1. A-181 material is limited by code to flanges of 150 and 300 lb primary service rating. The code also sets the maximum design temperature at 750 F.

The primary difference in ASTM A-181 and A-105 material is that A-105 is heat-treated for grain refinement. A-105 is used for all flanges designed for service above 750 F. And for 600 lb and heavier flange ratings regardless of temperature.

Flange Facings

The facings machined on the flange and the gasket used with it, are just as important as the type of flange or flange material specified. Fig. 3 shows the flange facings in common use.

The flat face is primarily for use on cast-iron flanges, or steel flanges bolted to a cast-iron flange. It should be used with a full-face gasket. This combination protects the flange from overstress and breakage. As the unit gasket-compression factor is very low, this facing should not be used for high pressure or volatile materials.

The raised face is the most common flange facing. The face of the flange from the inside of the bolt circle outward, is relieved 1/16-in. on 150 lb and 300 lb, and ¼-in. on 400 lb and higher class flanges. The raised face with the proper gasket, is applicable to pressures up to the 600 to 900-lb range, depending upon temperature. But it is seldom used at temperatures above 600 F with pressures over 50 lb.

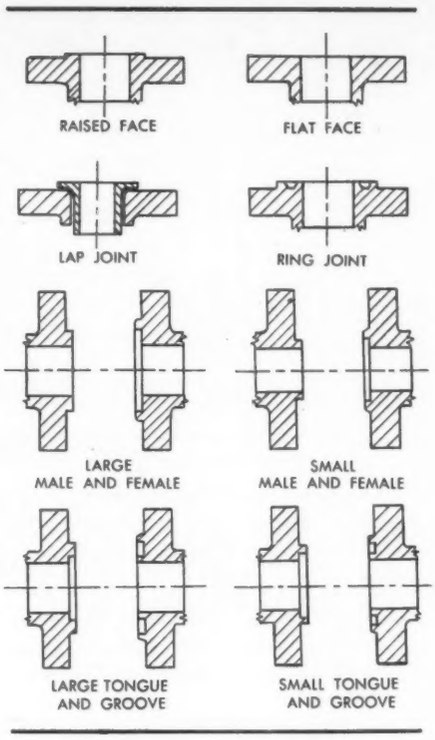


FIG. 3. Typical flange facings.

The tongue and groove and male and female facings, are applicable when it is desirable to have a facing that retains the gasket. The small tongue and groove has a very narrow gasket surface. And in addition to the retaining feature, it provides much higher gasket-compression factors with the same bolting.

Ring type joint facing using a ring groove contour different than the contour of the ring gasket is almost universally used for high-pressure applications. The contact area is reduced so that lower bolt-loading provides suitable compression for a seal. The ring is retained against blowout by the groove. The ring joint is a natural when a safe, tight joint is desired in a critical service.

Lap-joint stubs are upset to the same diameter as the normal raised face. On special order any of the standard facings can be machined into the upset face.

Flange Pointers

The ASA ratings for flanges are based on non-shock pressures. Codes in general do not specify the exact allowance to be made for shock or vibration. The designer must make allowance for this factor. When flow of a fluid is stopped abruptly, the shock pressure is 40 to 60 times the velocity in feet per second. For example, if a fluid flowing at 10 ft per second is interrupted, the shock pressure will be in the order of 500 lb. That is in addition to static line pressure. When pulsation or water-hammer effect is anticipated, flanges and valves must be designed accordingly.

The 150-lb rating ASA flange is proportionately the weakest of the group. Actual practice has shown that in gasoline plant services, many leaky joints will result when the 150-lb flange is used near its design limits. Most valve manufacturers do not recommend their 150-lb valves for services exceeding 500 F regardless of pressure. The principle is a good one and applies to other services as well.

Only four bolts are used in the 2 and 3-in. size flange in the 150-lb series. Apparently, the bolt spacing is such that the gasket pressure is not uniform due to flange deflection. Many designers use 300-lb rating flanges instead of 150-lb in the 2 and 3-in. size. This is especially good practice at pressures in excess of 175 psi, or when external line-stress may be more than nominal.

Gasket Function

The function of a gasket is to maintain a tight seal between two separable members of a joint assembly. The seal is effected by the yield or flow of the gasket material into the imperfections of the flange faces. The total contact area must be sufficient to hold internal pressures, and the gaskets must be resilient enough to take up slight differences in flange alignment. The gasket material must be resistant to attack by the line contents.

Gasket Characteristics

The choice of a gasket depends upon fitting gasket characteristics to the design conditions of the service. The gasket seating-stress is independent of the internal pressure. It is a measure of the force required to make the gasket material yield, flow, and seal the joint. The gasket factor is the ratio between seating-stress and the internal pressure. The seating-stress and gasket-factor values depend on hardness, resilience, and dimensions. ASME and most manufacturers publish tables of yield-point and gasket-factor values for common materials. The values for the same materials vary, due to different manufacturing practices. The tabulated values are fine for general design, but when joints will be working close to their maximum rating, test values obtained from the manufacturer should be used.

Gasket Applications

All raised-face flange types use a flat ring gasket. The gaskets are made from any material from paper to solid metal. Smooth ring-gaskets have an inside diameter the same as the pipe diameter. The outside diameter fits just inside the bolt circle. Rubber and compressed asbestos are the two most common flat-gasket materials. The service sheet

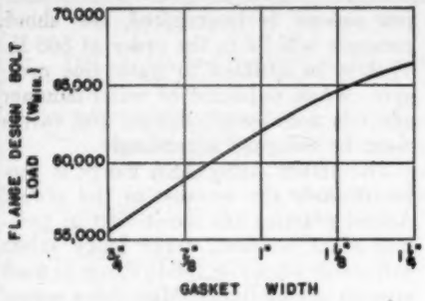


FIG. 4. Flange design bolt load with variying gasket width. Based on 6-in. 300-lb flange using sheet gasket. Assumed yield of 4500, gasket factor of 25. Design conditions 600 psi at 100 F.

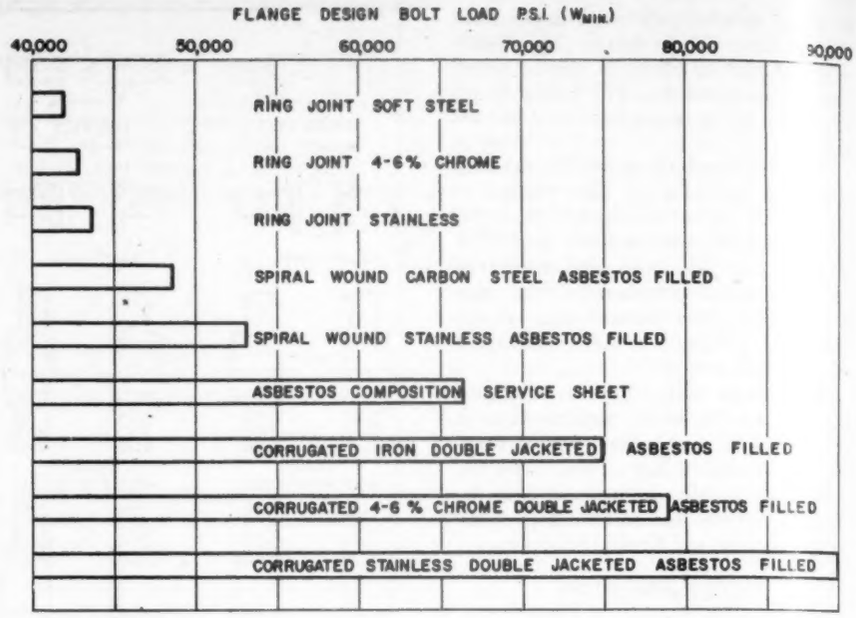


FIG. 5. Design bolt loads—common gasket materials. Based on 6-in. 300-lb ASA flange at 600 psi at 100 F.

gasket, 1/16-in. thick is practically a standard specification for utility and general hydrocarbons service in the 150 and 300-lb flange series at temperatures up to 450 F.

When design temperatures are over 450 F, gaskets of the service sheet type are not always dependable. The corrugated iron, asbestos filled, double-jacketed gasket was standard for higher temperatures only a few years ago. The spirotallic or flexitallic-type gasket is more widely used now. This gasket is satisfactory in carbon steel for temperatures up to about 600 F. Type 304 stainless is used from 600 F to 850 F. The spiral-wound gasket is also especially suitable when extreme variations in pressure or temperature are expected. Due to the gasket construction it is more resilient than other gasket types. In services where blowout would be critical, the spiral wound gasket can be supplied with a retainer ring.

The ring-type joint has the reputation of being the best bet for critical services. It is used almost without exception for all flanges of 600-lb ASA rating and over. Soft iron rings are used up to about 900 F. Alloy rings are available for higher temperature service and corrosive conditions.

Sample calculations were made for a 6-in. 300-lb ASA flange using a sheet gasket. Fig. 4 shows how the boltload increases as the gasket width is increased. Fig. 5 shows expected bolt-loading using ASME suggested values for yield and gasket factor. The flange design bolt-load divided by the bolt design-stress, gives the net bolt-area required for a joint in each case.

Flange Bolting

The most neglected factor in piping-design is often the flange bolting. Actually, many joint failures blamed on flanges and gaskets are due to bolting and its installation. The allowable design-stress values for bolts are based upon 20 per cent of the specified minimum yield-strength, or 25 per cent of the yield-strength required for 0.2 per cent offset, whichever is lower. In order to insure that flange bolting is not overstressed, the bolting must be specified to suit the gasket used. And the bolts must be tightened correctly.

Machine bolts should not be used for any but low temperature, low-pressure utility services. The specifications are just not rigid enough to insure a uniformly satisfactory bolt. Heat-treated, carbon-steel studs equal to ASTM A-261, have a wide field of application in less critical process lines. These studs are suitable only for 150-lb ASA flanges operating below 450 F. Regardless of quality or heat treatment of carbon-steel studs, the maximum allowable design-stress is 25 per cent of 55,000 multiplied by a factor of 0.92. For flange design conditions outside the carbon-steel class, it is common practice to call for ASTM A-193 Grade B-7 chrome alloy. This material is equal to SAE 4140 and crane triplex.

All of the alloy stud materials may be provided with varying heat treatment to provide different physical properties. Commonly stocked stud material has a tensile of 125,000 psi and a yield of 105,000 psi. With other heat treatment, the tensile may vary from 160,000 psi to 99,000 psi. The yield varies from 160,000 to 80,000 psi. In high-pressure piping, it sometimes is desirable to adjust the gasket width or type, and call for special studs in order to make standard flanges handle the working pressure. The relationship between tensile strength and number of bolts is illustrated in Fig. 6. This figure is based upon a 6-in. 300-lb flange working at 600 psi and 100 F. The calculations are on the basis of a compressed asbestos service-sheet gasket.

Summary

All the elements of a flanged joint must be balanced and work together if the joint is to be satisfactory. There are the same number and size of bolt-holes in all types of standard flanges. This means that the bolt-area is set. The tensile strength of the bolts then must be great enough to properly compress the gasket specified, and the flange facing must be suitable for that gasket.

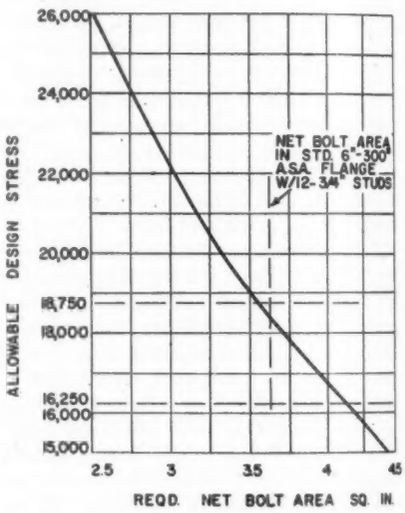


FIG. 6. Required net bolt area with different stud materials. Based on 6-in. 300-lb ASA flange with sheet gasket.

Both gaskets and bolts are cheap compared to other items in the piping assembly. In each instance, the best material for the service should be specified. If there is any doubt, use the next material better than the one that might do the job. Many times bolt-stress is greater than the designer can anticipate. Line movement may overstress a joint. Lack of control over bolt tightening procedure may cause trouble. It is important that flange bolts be tightened uniformly, in sequence and equally stressed with final loading applied in small steps, if distortion is to be avoided.

(Part 8 will be published soon.)

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☐ **MULTI-POINT INDICATORS.** Will indicate, on separate vertical scales from two to sixteen units of draft, pressure, flow, temperature, CO_2, etc., in any combination desired.

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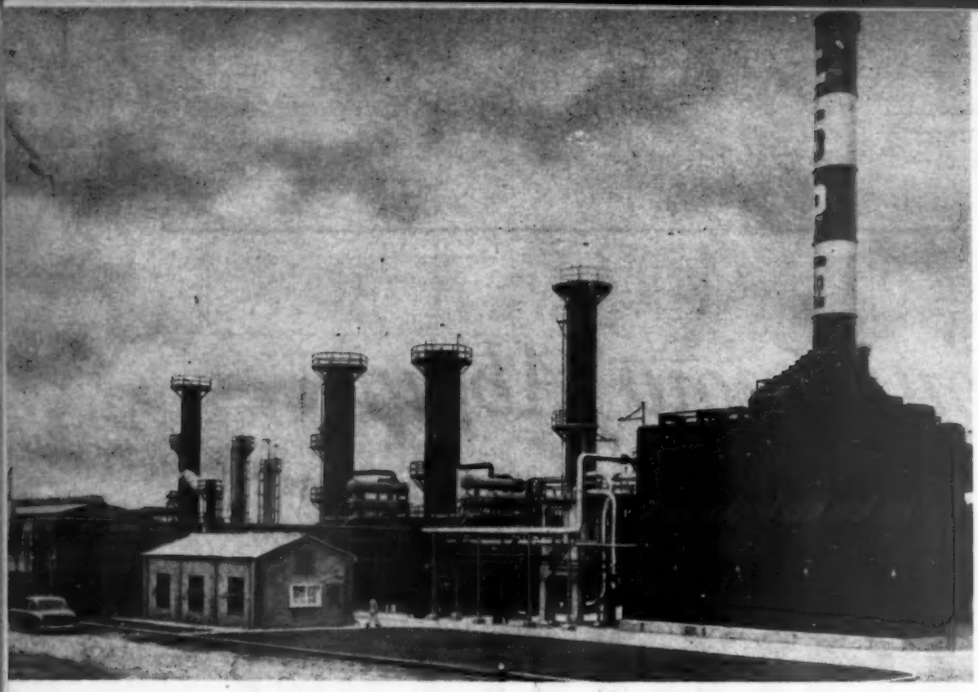


General view of Eastern States new Platformer-Udex combination, the first commercial application of this new team.

Control System for First Platformer-Udex Unit

H. M. MARTIN*

ONLY 50-odd years ago petroleum producers and refiners were primarily concerned with increasing yields of lamp oils, while light naphthas enjoyed only a limited market. With the advent of the internal combustion engine, however, early in the 20th century, the production of gasoline fuel gradually eclipsed that of all other types of petroleum products.

The gradual evolution of the simple internal combustion engine to a high compression power plant, with its insatiable appetite for higher and still higher "octane rating," created a new demand for a gasoline with more desirable combustion characteristics.

The current scene reveals two related trends in refining technique. The first of these is in the direction of improved "high octane" gasoline through a "reforming," or chemical rearrangement of the molecules of straight-run gasoline. A concomittant objective is the increasing production of vitally needed lower aromatics. These include benzene, used principally in the production of synthetic rubber, plastics and a variety of critical chemicals, and toluene and C_8 aromatics, both of which are utilized in aviation gasoline.

Keeping pace with these trends, Eastern States Petroleum Company recently placed on stream the first of Universal Oil Products Company's Platformers for the production of aviation base stock. In order to separate the yield of aromatic hydrocarbons (principally benzene and toluene) from the motor fuel Platformate, a Udex* unit was added, marking the first commercial application of these two processes as a team.

Platformer and Udex Units

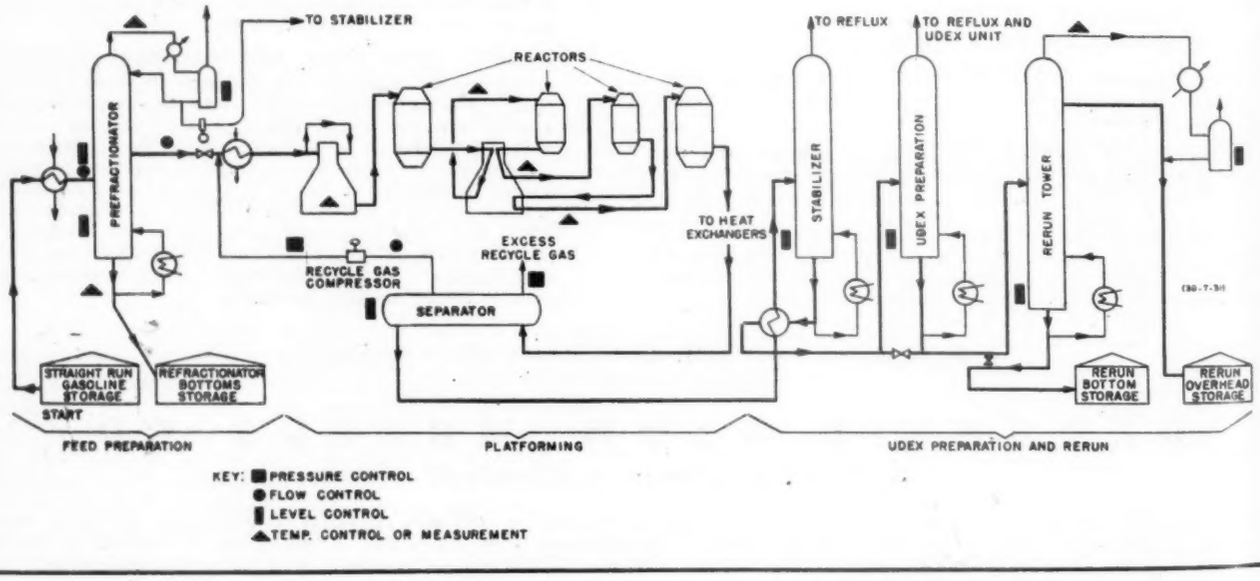
"Platforming" is the reforming of straight-run gasoline in the presence of hydrogen, using a platinum catalyst. The hydrogen prevents carbon formation, and a reasonable hydrogen-gas recycle rate is maintained in order to make the process non-regenerative.

The three major reactions which occur are: (1) dehydrogenation of naphthenes to aromatics, (2) hydro-cracking of high molecular weight hydrocarbons to smaller-chained aliphatics, and

*Chief Engineer, Eastern States Petroleum Company, Houston.

*U, from Universal Oil Products Company, which developed the process; D from the Dow Chemical Company which discovered the process; and EX, extraction.

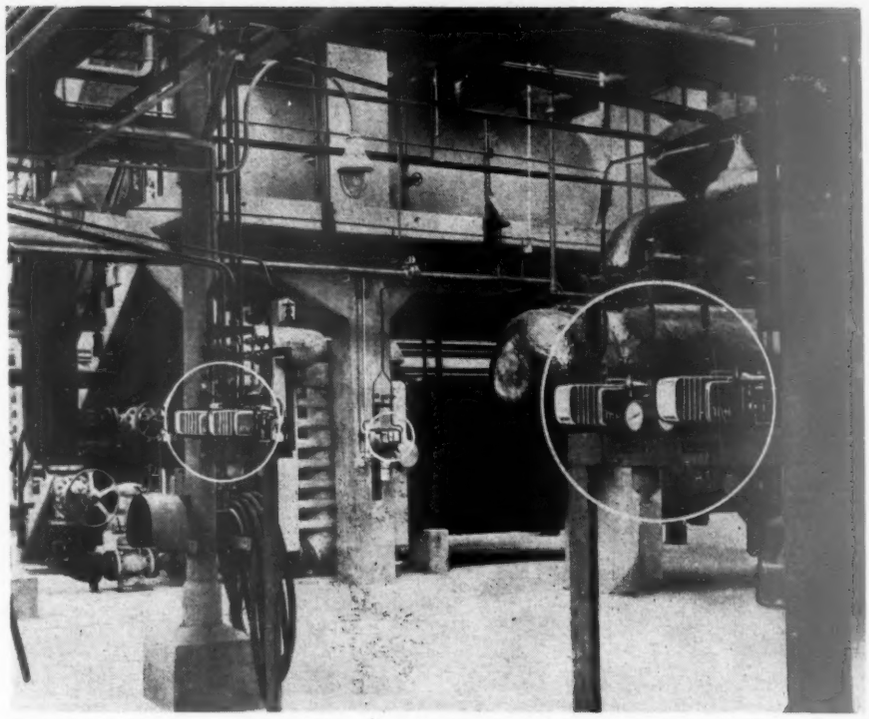
FIG. 1. Simplified flow diagram of Platformer-Udex. Points of measurement and control are indicated by geometric symbols.



(3) isomerization of 5-membered ring naphthenes to six-membered rings, prior to conversion to aromatics. In addition, some paraffins are converted directly to aromatics while virtually all of the combined sulfur is converted to hydrogen sulfide.

The simplified flow diagram is that of the Eastern States' unit for aviation base stock production. Following preheat by exchange with reactor effluent, the straight-run gasoline charge is prefractionated. Charge for the reactors is drawn from the prefractionator as a side stream. A heated hydrogen-rich recycle gas joins the reactor charge and the mixture is preheated prior to entering the reactors, where "Platforming" takes place. The product gases (hydrogen sulfide and excess recycle gas) are removed as overhead from the separator, while the liquid product (Platformate) passes to a stabilizer and then to a Udex preparation tower.

Bottoms from the Udex preparation tower are pumped to a re-run tower where an amount of heavy components that boil above the gasoline range are removed, as bottoms. When these components are not present in the Platformer charge, the re-run is eliminated. Overhead, from the preparation tower, is pumped to the Udex unit, where the aromatics are extracted from the feed stock by counter-current flow of diethylene glycol. The aromatics (principally benzene and toluene) are then steam-stripped from the glycol.



Mercuryless differential converters measure process flows and transmit a 3-15 psi air signal to instrument panel.

Control of Process Variables

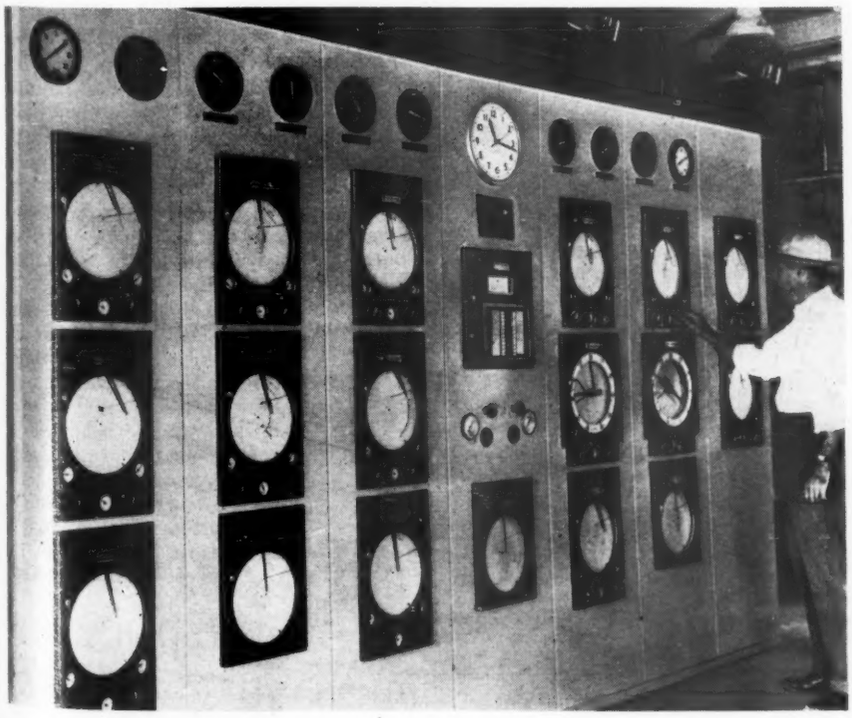
Maximum efficiency in plant operations is effected through control of four major process variables. These are temperature, pressure, hydrogen recycle rate, and space velocity, which represents a ratio of barrels of charge per hour to barrels of catalyst.

"Platforming" at the Eastern States' plant is accomplished at relatively low temperature, pressure and space velocity.

Under the mild temperature conditions, the reaction remains truly catalytic. Undesirable and relatively irreversible side reactions, such as ring opening and demethylation, are minimized. One of the chemical changes which takes place, hydro-cracking, is exothermic and therefore provides some of the heat of reaction. This reaction is retarded in favor of dehydrogenation (endothermic), thus essentially eliminating any tendency of the reactors to develop runaway temperatures. The result is a more easily controllable process, as far as temperature is concerned.

The low pressure limit is set so that the desired amount of hydrocracking will be obtained. If the partial pressure of hydrogen is maintained at a low level for a prolonged period, a tendency exists for carbon formation, a condition overcome by providing a prescribed recycle gas rate.

Control board on Udex unit. More than half of instruments shown are used to measure and/or control flows such as benzene tower charge. The balance of instruments are used in measurement and/or control of temperature, pressure and liquid level.

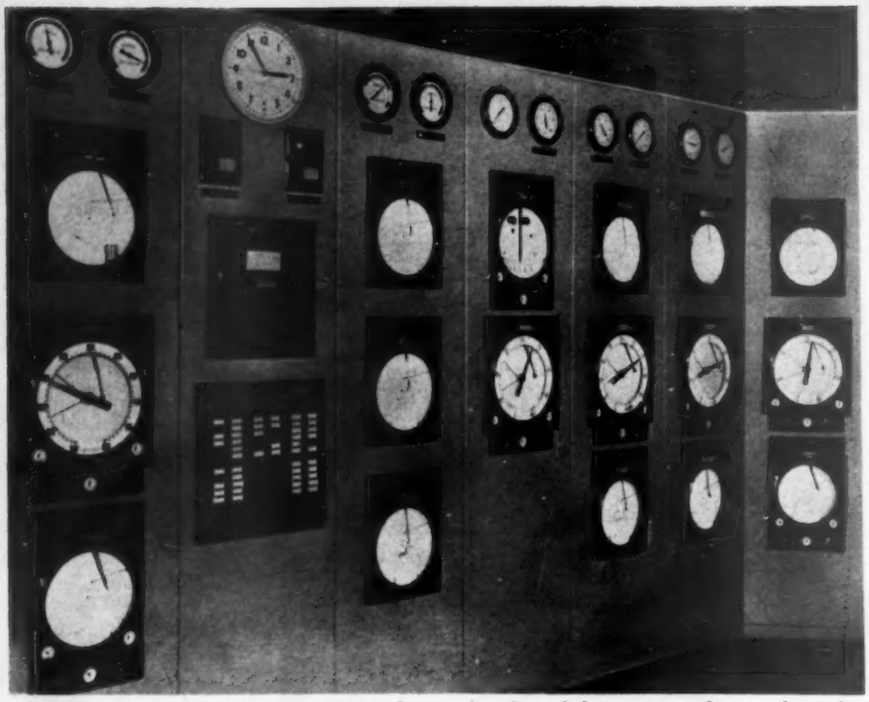


Instrumentation

All instrumentation for control of these operating variables was supplied by the industrial division of Minneapolis-Honeywell Regulator Company, with field representatives of the company performing much of the instrumentation engineering.

Although the use of a graphic panel was considered, the minimum time available for its construction precluded any possibility that it would be completed and installed by the time the Platformer-Udex was ready to go on-stream. Accordingly, the contract was let for a conventional type panelboard. Indications are that the degree of control furnished by this type instrumentation is more than adequate, as far as this particular processing unit is concerned.

Notwithstanding the fact that this plant was placed on-stream in record



Right section of all-Brown panelboard on Platformer unit. The over-all board is constructed at a 90 deg angle parallel to two walls of the control house.

engineering and construction time, the instruments were delivered and completely installed by the time the Platformer unit was completed.

All temperature instruments are ElectroniK potentiometers. These are mounted on 2 centrally located control boards, one for the Platformer and one for the Udex unit. In the former, temperature control is maintained on overhead and bottom products of prefractionator, stabilizer and re-run towers, as well as in the heaters and 4 reactors. A multi-point electronic precision indicator provides the means for manually checking these points as well as other miscellaneous temperatures. Temperature is controlled on the stripper and benzene tower in the Udex unit, and a check of these and other temperature points are provided by a 16-record precision indicator.

Pneumatic transmitters are employed on the other variables (with the exception of process-mounted liquid-level controllers) so that no hydrocarbon or hydrogen piping enters the control room, where the pneumatic controllers are mounted on the control board. Differential converters, employed for the measurement of fluid flows, transmit 3 to 15 psi air signals to board-mounted instruments. The use of these mercuryless meters has eliminated the nuisances of emulsification and sealing fluids, as well as the condenser pots which are required on steam lines when the mercury-type differential pressure meters are employed.

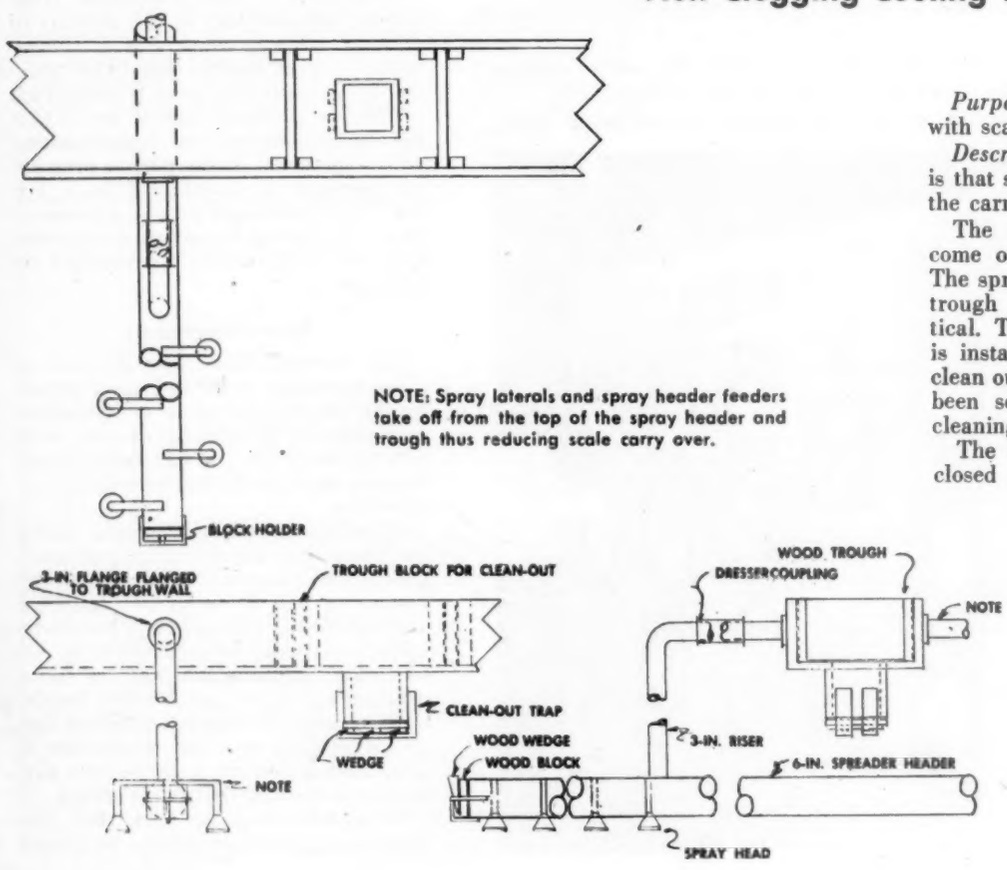
Pressure of hydrogen gas recycle is controlled by a pressure recording controller on the product separator. The gas compressor takes suction on the separator, with pump suction on the prefractionator. Flow of recycle gas is controlled to provide optimum conditions for inhibiting carbon formation on the catalyst.

The entire system is well-integrated, providing efficient control of all operating variables. * * *

PLANT AIDS

Non-Clogging Cooling Tower Spray Headers*

GEORGE ZORNS†



Purpose: Prevent clogging of sprays with scale from tower.

Description: The basis for this system is that scale is carried at the bottom of the carrier.

The individual sprayhead laterals come off the top of the sprayheader. The sprayheader feed lines come off the trough at as near the top as is practical. The tower in which this system is installed is a thirty day tower and clean out boxes and trough blocks have been set every ten days to allow for cleaning the trough

The ends of the 6-in. spreaders are closed with redwood blocks held in place by wedges. To clean the headers, the wedges and blocks are removed, this flushes out the headers.

Previous to installing this system, one man was busy in the tower at all times. This system has now been in operation for six months and has yet to require attention.

*Class D, first prize at NGAA—Permian Basin regional meeting.

†Chief operator, Phillips Petroleum Company, Hobbs plant, Hobbs, New Mexico.

Gage for Underground Pressure—Dumped Oil Sump

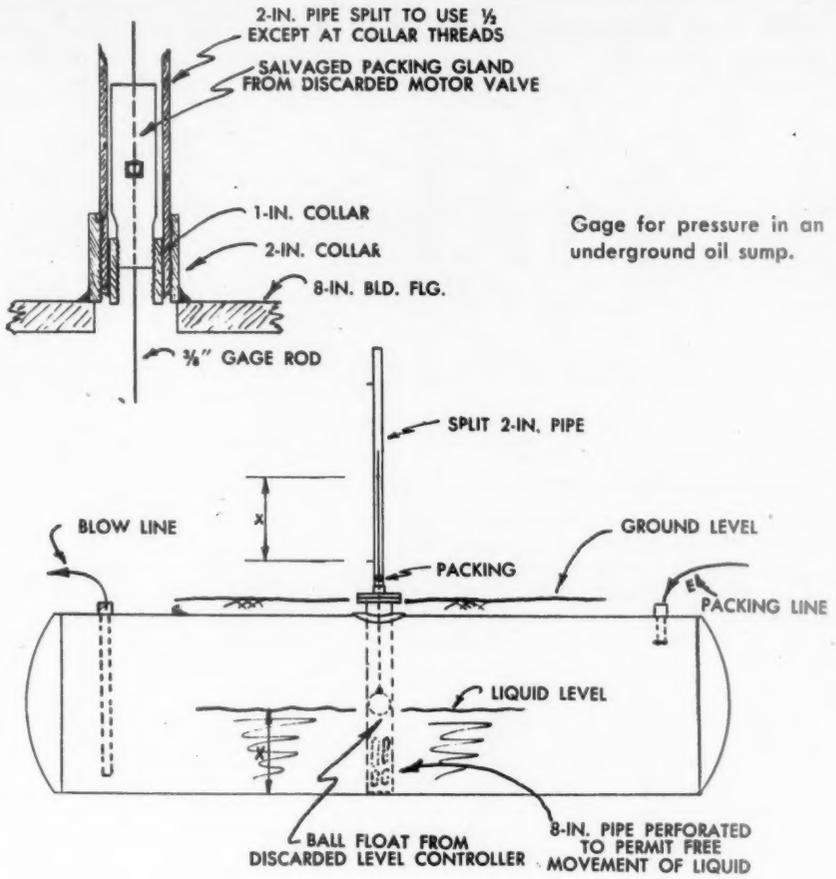
H. O. TRUE†

Purpose: To have a constant gage of the liquid level in an underground sump by utilizing salvage parts.

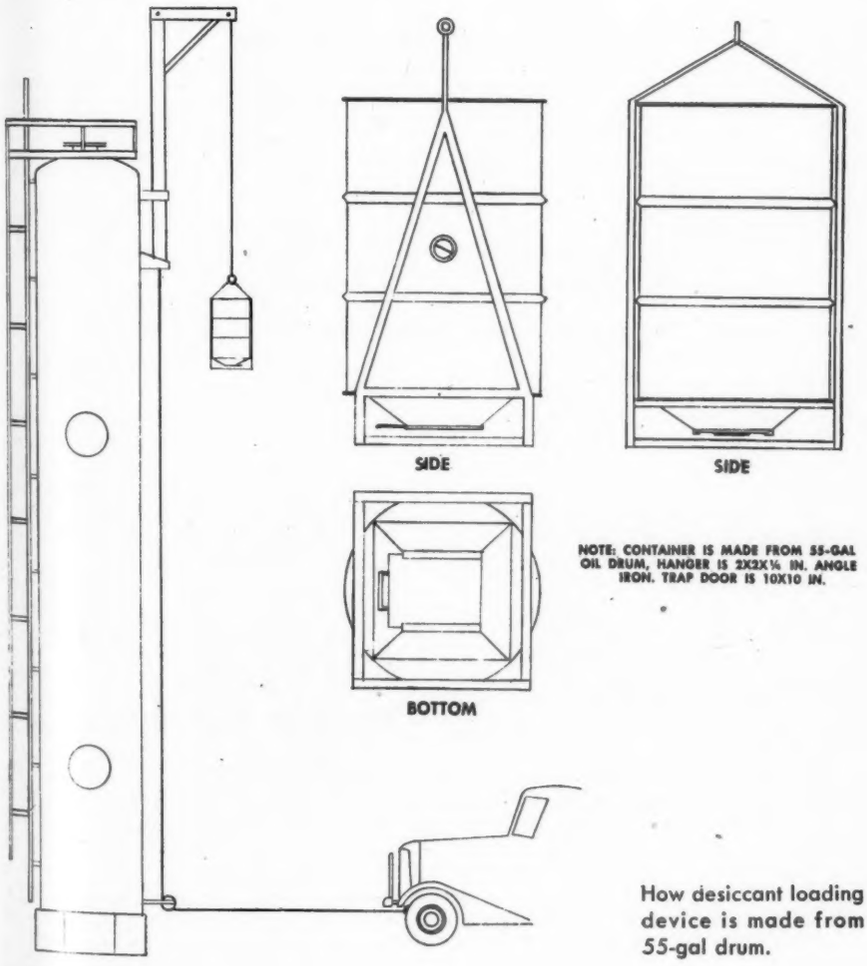
Description: An 8-in. pipe was run down to the bottom of the sump and perforated to allow free movement of liquid. A flange was placed on the 8-in. pipe and the pipe was welded to the tank opening with a pad. A hole was cut in a blind flange to permit passage of the gage rod. A ball float salvaged from a level control was attached to the bottom end of the gage rod. A 2-in. pipe was split in half except where it threaded into the collar welded on the blind flange. Thus, the ball floats on the liquid in the sump, moving the rod above ground. A seal was accomplished by utilizing a discarded motor valve packing gland. The sketch shows the general arrangement of the various parts.

This gaging device has proved successful in use and costs very little to install. It shows an accurate gage during dumping.

*NGAA—Permian Basin regional meeting.
†Plant superintendent, Phillips Petroleum Company, Crane, Texas.



Gage for pressure in an underground oil sump.



How desiccant loading device is made from 55-gal drum.

Desiccant Loading Apparatus*

O. F. HAMILTON†

Purpose: To provide a fast economical method of loading desiccant into the residue gas dehydrators.

Description: The desiccant loading apparatus for filling gas dehydrators is made from a 55-gal oil drum. The oil drum is altered by removing the top and providing a sliding trap door in the bottom to facilitate the dumping of the desiccant. The bottom of the drum is sloped to allow all of the desiccant to fall through the 10 by 10-in. trap. The altered barrel is then placed in a hanger made of 2 by 2 by ¼-in. angle iron and welded in position. A drum rigged in this fashion will hold three 125 lb sacks of Florite desiccant.

The loaded drum is hoisted into dumping position at the top of the tower by means of a cable threaded through the pulleys of a center-haul davit and attached to the frame of a truck. By driving the truck back and forth the loaded drum can be quickly hoisted to the top, dumped and returned to the ground.

*NGAA—Permian Basin regional meeting.
†Gang pusher, Stanolind Oil and Gas Company, Andrews, Texas.

☆ ☆ ☆

Over a recent 12-month period, some 500 new petrochemicals appeared on the market and went into the service of industry, agriculture, and the home.

NEWS

Fluor Gets American Liberty Contract

D. R. Zachary, executive vice president of American Liberty Oil Company, Dallas, Texas, has announced that The Fluor Corporation, Ltd., Los Angeles, California, and Houston, Texas, has been awarded the engineering and construction of a feed preparation unit, TCC unit, gas fractionation unit, and the modification of their existing poly plant for its Mt. Pleasant refinery at Mt. Pleasant, Texas. All engineering for these new facilities will be performed by Fluor's Mid-Continent division at Houston, Texas.

Bureau Lab Recovers Oil From Utah Sandstone

Tests on bituminous sandstone from two large deposits in Utah gave promise that most of the bitumen, a heavy crude oil, could be recovered and then processed successfully into gasoline and other fuels, Secretary of the Interior Oscar L. Chapman made known in releasing Bureau of Mines report of Investigation 4871.

Bituminous sandstone deposits are likely to provide additional petroleum reserves when conditions for the development are favorable. The Bureau has been studying the recovery and use of bitumens in the United States for several years.

Samples tested were from deposits near Vernal and Sunnyside, Utah, which are estimated to contain at least 2 billion barrels of bitumen. This is the equivalent of about 40 per cent of the petroleum found in the Nation's largest oil field—the East Texas field.

Using a thermal cracking process in the laboratory, about 13 per cent of the bitumen was then recovered as gasoline. Bureau tests also proved that the bitumen could be used to produce diesel fuels, other heating distillates, and residual fuels. Other tests indicated that asphalts suitable for paving and other uses probably could be produced.

A free copy of the publication may be obtained from the Publications Distribution Section, Bureau of Mines, 4800 Forbes Street, Pittsburgh 13, Penna.

New Lithium Chemical Plant

What will be the world's largest lithium chemical plant is to be constructed at Sunbright, Virginia. This modern plant, which is expected to be in operation by the middle of 1953, will more than double the current capacity of the entire industry in the production of lithium chemicals.

To supply Spodumene, the basic raw material for this plant, Foote is now expanding its mining, milling and processing facilities at Kings Mountain, North Carolina. From what is regarded as the largest known commercial deposits of lithium ore in the Western Hemisphere, Foote will more than triple its output of Spodumene to supply Sunbright and the ceramic industry.

Record Refining Capacity Now Building in U.S.

Construction of additional refining facilities totaling 819,000 bbl per day has been started since the beginning of the controlled materials plan instituted in 1951, according to announcement by Deputy Petroleum Administrator J. Ed Warren. The industry plans for a total of 1,215,000 bbl a day of new construction, Warren stated.

On July 7, 1952, some 92,950 bbl a day of new capacity has been completed. New capacity of 528,600 bbl a day is expected to be completed by January 1, 1953. By July 1, 1953 new capacity completed is expected to be 742,460 bbl a day and by January 1, 1954 the total is expected to be 1,078,100 bbl a day. Some of the current construction may be delayed by as long as three months, PAD believes, by the recently ended labor strike in steel.

Of this new building, the industry has completed 87,190 bbl a day of new catalytic cracking capacity, of a planned total of 563,000 bbl a day to be completed by 1954. Total new cat cracking capacity for which applications have been made brings this grand total up to 687,000 bbl a day, or 56 per cent of new crude-running capacity. Industry has plans for 221,295 bbl a day of cat reforming capacity, construction of 86,565 bbl of which has been started.

Below are tables giving figures:

New capacity for crude oil processing

(As of July 7, 1952)

	Barrels per day					
PAD District	1	2	3	4	5	Total
1. Construction completed	6,000	51,800	28,150	0	7,000	92,950
2. Construction started (Incl. No. 1)	201,100	296,990	267,800	11,592	41,725	819,207
3. Estimated completion (Incl. No. 1)						
By January 1, 1953	75,210	183,290	217,510	11,592	41,000	528,602
July 1, 1953	132,960	273,360	280,850	14,292	41,000	742,462
January 1, 1954	209,100	405,860	375,690	15,292	72,165	1,078,107
Later	229,100	453,860	436,890	15,292	79,890	1,215,032

New capacity for catalytic cracking

(As of July 7, 1952)

	Barrels per day of fresh feed					
PAD District	1	2	3	4	5	Total
1. Construction completed	2,300	19,050	56,340	0	9,500	87,190
2. Construction started (Incl. No. 1)	143,600	103,100	245,040	12,500	58,800	563,040
3. Estimated completion (Incl. No. 1)						
By January 1, 1953	21,000	78,110	128,640	12,500	39,370	279,620
July 1, 1953	45,100	108,110	165,240	16,400	39,370	374,220
January 1, 1954	143,600	116,580	296,040	21,150	45,370	622,740
Later	152,480	116,580	330,440	21,150	66,170	686,820

New capacity for catalytic reforming

(As of July 7, 1952)

	Barrels per day of charge					
PAD District	1	2	3	4	5	Total
1. Construction completed	0	0	10,920	0	0	10,920
2. Construction started (Incl. No. 1)	22,500	27,780	28,025	0	8,260	86,565
3. Estimated completion (Incl. No. 1)						
By January 1, 1953	1,500	20,880	33,120	0	0	55,500
July 1, 1953	1,500	25,920	42,705	0	0	70,125
January 1, 1954	22,500	68,890	56,205	0	26,090	173,685
Later	30,850	76,890	79,205	0	34,350	221,295

Standard Cal Begins New Catalytic Cracking Unit

Standard Oil Company of California will build a new catalytic cracking unit at its El Segundo (California) refinery at a cost of more than $20,000,000, it was announced by T. S. Petersen, Standard's president.

"The purpose of this unit will be to convert heavy fuel oil into aviation gasoline and high grade automotive fuels, which are steadily increasing in demand," Petersen said. "Capacity will be 36,000 bbl daily.

Petersen said engineering work on the El Segundo project will begin immediately. Actual construction is expected to begin in mid-1953, with completion scheduled for 1954.

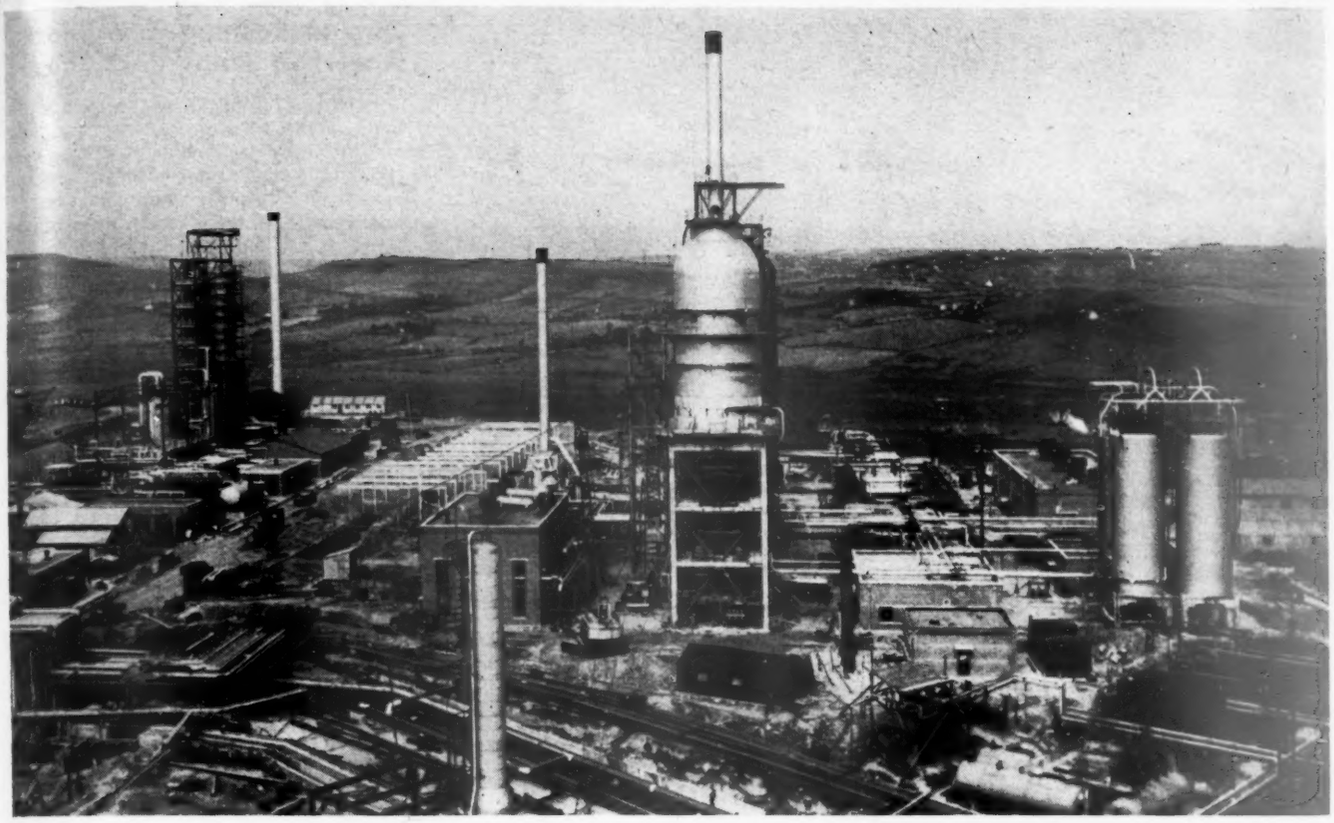
The new unit will include a feed stock preparation unit capable of handling 54,000 bbl daily of heavy fuels. It also will include facilities to recover H2S gas for conversion into sulfuric acid.

Petersen pointed out that one of its derivatives will be used in the manufacture of a compound called cumene, at a separate unit to be built in 1953 at El Segundo.

This cumene will be shipped to the company's Richmond refinery, in Northern California, for processing into phenol, which in turn is used in the manufacture of resins for moulded plastic parts, plywood adhesives, and as an intermediate in the making of dyestuffs, insecticides and many other compounds. Design work on the $4,000,000 phenol plant is under way and construction is scheduled to start later this year.

Empire to Expand Refinery

Empire Petroleum Company announced plans to increase capacity of its refinery at Denver, Colorado, from 1500 bbl a day to 5000 bbl a day. E. M. Stone company president, said Empire, which has a contract to deliver 850 barrels a day of its refinery output to Bay Petroleum Corporation, now buys it crude but plans to develop its own production.



Llandarcy Cracker Over 85 Per Cent Complete. Construction of a 10,000-bbl-per-day Fluid catalytic cracker in Llandarcy, Wales, is more than 85 per cent complete. The Llandarcy cracker is one of three similar units in the British Isles being constructed under the supervision of Kellogg International Corporation. Photograph released by M. A. Kellogg Company, supervisor of construction of the plant. The other two units are situated at Kent, England, and Grange-Mouth, Scotland.

Sulfur Shortage Ended Freeport Head Reports

The world sulfur shortage, critical since the outbreak of the Korean War, has improved to the point where virtually all sulfur requirements in the United States are being met, Langbourne M. Williams, Jr., president of Freeport Sulphur Company, declared. Furthermore, he added, the outlook for the future is "extremely encouraging" as a result of nearly 100 new projects in the United States and other free world countries that will substantially increase the supply of sulfur in various forms. These projects are expected to add 1,500,000 long tons by the end of 1952.

These projects, it is estimated, will add approximately 4,000,000 long tons of sulfur per year by the end of 1955, he said. This amount is equivalent to one-third of the estimated 1951 free world production of about 12,000,000 tons of sulfur in all forms.

"The large gap between sulfur supply and demand no longer exists," Williams said. "Although sulfur consumption is still under government limitation, all but a few consumers in this country are getting all the sulfur they need, and the situation abroad has also improved."

Witco Stills Installed

Witco Chemical Company has installed three new stills, two of 100-ton and one of 50-ton capacity, for making roofing and paving asphalt at the company's Perth Amboy, New Jersey plant.

Chemical Group Presents Program on Atomic Devices

A comprehensive program of ten papers summarizing the status of the industrial applications of atomic energy, each by an expert pre-eminent in his field, are being given at the Seventh National Chemical Exposition in the Chicago Coliseum, September 9 to 13.

The speaking program, set for all day and evening, September 11, will be tied in with a special exhibit on atomic industrial devices, presented through the cooperation of the Atomic Energy Commission and the Chicago Section of the American Chemical Society, sponsor of the Exposition.

Leading the list of speakers will be Eugene M. Zuckert, member of the Atomic Energy Commission, who will address the evening session on "Atomic Energy and the Citizen of the Future."

Speakers also include: S. E. Eaton, Arthur D. Little; Dr. George G. Manov, and J. H. Hayner, Atomic Energy Commission; Dr. Charles Rosenblum, Merck and Company, and others.

Buckner Succeeds RMC

F. J. Buckner Corporation has announced it is now successor to the Refinery Maintenance Company, Inc., of Compton, California. Buckner will continue general construction and engineering, specializing in the refinery and oil industry.

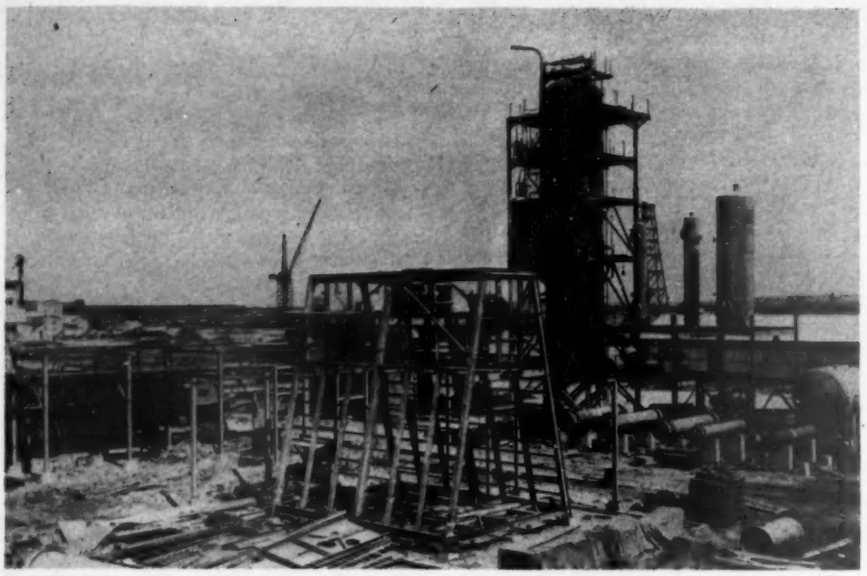
The new company is headed by F. J. Buckner, as president, who has spent 25 years in this field.

Atlantic Announces First Use of New Process

The Atlantic Refining Company has announced that the first commercial plant using Atlantic's new catalytic reforming process has been put into operation at the oil refinery of the McBride Refining Company, LaBlanca, Texas. This unit has a daily capacity of 750 bbl. The new process, which will produce greater amounts of high quality gasoline from a given amount of crude oil than any previous refining method, was developed by Atlantic scientists after four years of intensive research. The process is designed to produce the higher octane gasoline required by the new high compression automobile engines.

Plans for Benzene Output Exceed Defense Goals

Industry plans for production of benzene from petroleum exceed the Government's defense mobilization expansion goals as presently planned the Petroleum Administration for Defense has announced. A program calling for construction of new facilities for producing 8450 bbl a day (130,000,000 gal) of benzene from petroleum sources was approved in 1951 by the Defense Production Administration. As of mid-June 1952, on the basis of recommendations by PAD, DPA had approved certificates of accelerated tax amortization covering facilities for producing this same amount of benzene from petroleum.



England's Initial Propane Deasphalter. Anglo-Iranian Oil Company, Ltd.'s new refinery at Kent, England is now under construction. This will be England's first propane deasphalter. It will have a fresh feed capacity of 4500 bbl per day. In the foreground, is the steelwork for an "A" frame heater. As may be seen, the main tower, strippers, and secondary fractionator are already in place, as are a number of the heat exchangers. Unit is being built by Kellogg International Corporation.

Radioactive Tracers Check Flow Rates of Catalyst

An unusual application of radioactive tracer technique was developed recently at Salt Lake Refining Company's Houdriflow catalytic cracking unit at Salt Lake City, Utah. In this unit cracking is accomplished by bringing oil vapors into contact with a solid moving bed of bead catalyst passing downward through the reactor and regenerator. Uniform flow of catalyst is necessary for maximum operating efficiency. The determination of flow rates of solid particles inside cracking vessels poses a problem, however.

Engineers of the California Research Corporation conceived the idea of introducing into the unit a few pellets of catalyst impregnated with a radioactive substance. The travel of individual radioactive particles was traced by means of Geiger counters at points along the catalytic equipment.

The survey proved that catalyst circulated through all parts of the Houdriflow unit with excellent uniformity. For example, the average velocity of catalyst particles flowing down the main seal leg from lift disengager into reactor was measured repeatedly over a period of several weeks with a maximum deviation from the mean result of less than 5 per cent.

Unit Will Boost Gasoline

The output of high quality gasoline at Shell Oil Company's Wood River, Illinois, refinery will be increased by the addition of a new "platforming" unit, it was announced by F. S. Clulow, vice president. The new plant addition will have a capacity of 16,000 bbl a day.

Construction of the Wood River unit will begin immediately, according to Clulow. The contract has been awarded to Procon Inc., Chicago, which is building a similar unit, now nearing completion, for manufacture of aromatics at Shell's Houston, Texas, refinery.

Foreign Refining Expansion Ahead of Plans PAD Says

Petroleum refiners in free-world nations outside the United States are planning refinery expansion at a rate even faster than that proposed in the goal for expansion formally approved earlier this year, Deputy Petroleum Administrator J. Ed Warren reported to Secretary of the Interior Oscar L. Chapman.

The program approved by the Defense Production Administration at the request of the Petroleum Administration for Defense in April called for expansion of capacity at the rate of 384,000 bbl a day per year through 1953. Actually, Warren reported, more than 50 projects have been begun and are planned for completion in that period, and these would provide an increase at the rate of 400,000 bbl a day per year.

Refining capacity in foreign countries, excluding Soviet Russia and the Russian satellites, was about 5,000,000 bbl a day at the end of 1951 and will probably be 5,800,000 bbl by the end of 1953.

New Sulfur Plant Producing

Standard Oil Company (Indiana) has begun production of sulfur in a new plant at its Whiting, Indiana, refinery, which will help meet a world-wide shortage of this vital defense material.

The new plant will extract hydrogen sulfide from by-product fuel gases produced in the Whiting refinery and convert it into sulfur of 99.9 per cent purity.

What's Ahead For Gas Industry*

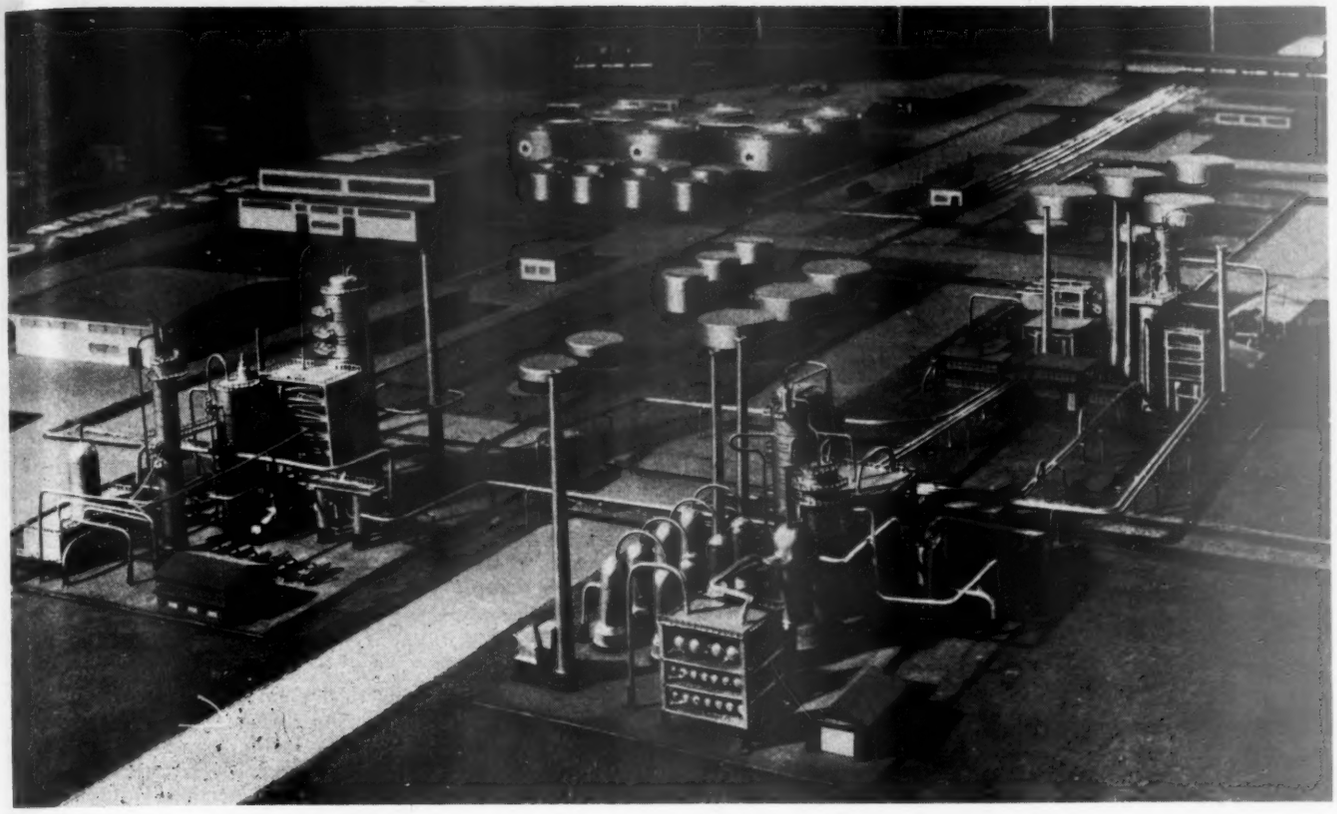
CLAUDE A. WILLIAMS†

Probably the biggest question in all of our minds is the adequacy of gas supply for the future. In my opinion, there is no doubt that there are ample gas reserves for the next 20 years to support the present contractural requirements of all the gas companies in the United States. But what about the expanding demands that we will encounter in the next four or five years? It is my belief that sufficient reserves will be available to accommodate this growth. However, most of this gas supply is now in the hands of individuals and companies that are unwilling to sell in interstate commerce. Had the Kerr bill not been vetoed, I am confident that many trillion cubic feet of gas reserves in the Gulf Coast area would have been available for the interstate gas pipe lines. As a result of this veto, we along the Gulf Coast are witnessing a minor industrial revolution in certain phases of the chemical industry, where in many processes natural gas is not only the fuel but the chief raw material as well. Abundant supplies of gas available for local intrastate consumption and the accessibility of water transportation has caused this migration of major industries to our section of the country.

Of the 106 trillion cu ft estimated to exist along the Texas and Louisiana Gulf Coast, I believe there are at least 30 trillion cu ft that are uncommitted to any gas company. These reserves are largely in the hands of three of four major oil companies. With the recent industrial activity, there is more incentive for the pipe line companies to sponsor a Kerr bill through the Congress than it is for the producer to do so because the development of the petro-chemical, aluminum, and other local industries will provide adequate intrastate markets to protect expiring terms of primary leases or prevent drainage as a result of the sale of gas by other producers from the same reservoir. Mainwhile, this increased demand together with additions to major pipe line projects has boosted gas prices to a new peak, encouraging its exploration at an accelerated pace that will result in the discovery of more and more reserves in both old and new potential gas-producing areas as the years go by.

*Excerpt from paper presented before American Gas Association, Natural Gas Department, Los Angeles, California, May 12-13, 1952.

†President, Transcontinental Gas Pipe Line Corporation.



Scale model of the refinery of SARPOM (Societa per Azioni Raffineria Padana Olii Minerali), owned jointly by the Fiat Company and the Caltex Group, and located at San Martino di Trecate.

Caltex-Fiat Show New Refinery Model of Italian Plant

A new refinery of 13,000 bbl per day capacity will be placed in operation in Italy sometime about October 1952 by the company, SARPOM (Societa per Azioni Raffineria Padana Olii Minerali).

The equal partners in this undertaking are the Fiat Company (Fiat, S.p.A.) and Caltex (Caltex Oil Products).

Advance notice to the Italian public—by means of a scale-model exhibit—was given to visitors to the 34th Automobile Show in Turin.

The presentation was made jointly by SARPOM, the refining company, and Petrolcaltex its marketing counterpart, also a 50-50 Fiat and Caltex Italian firm.

Situated inland, at San Martino di Trecate, between Milan and Turin, the refinery will be supplied with crude oil from the Mediterranean terminal at Savona via pipeline, 97 miles in length, passing over the Apennines.

Its products in turn, will serve a wide radius of the expanding industries of Italy.

Award Contracts for Expansion of Refinery

Richfield Oil Corporation has awarded contracts for the major portion of the $40,000,000 expansion of its Watson refinery near Long Beach, California, to C. F. Braun and Company, Alhambra, and Fluor Corporation, East Los Angeles. Work is expected to get under way immediately.

Braun will build a new fluid catalytic cracking unit and vacuum unit, a superfractionation unit in the same area as the fluid unit, revisions to combination units and crude batteries and completing installation of new boiler with pertinent water softening equipment, a new boiler house and yard, electrical and service lines.

Fluor has been awarded construction work involving additions and revisions to the existing alkylation unit, revisions to the existing superfractionation unit, new cooling towers and pertinent yard piping for new units.

Still to be awarded in this project are contracts for a new polymerization plant, various shops, warehouses and change rooms. The expansion project is scheduled for completion in 1954.

Plan Chemical Plant

General Petroleum Corporation, West Coast affiliate of Socony-Vacuum Oil Company, Inc., has sold a 140-acre plot of ground to Carbide and Carbon Chemicals Company, as the site for a $36 million polyethylene and ethylene glycol plant.

The site is adjacent to General Petroleum's Torrance, California, refinery. The chemical firm has entered into a 20-year contract with General Petroleum for supply of raw materials, principally ethylene.

The plant is being designed to produce 50 million to 60 million pounds of polyethylene and 5 million to 10 million gallons of ethylene glycol a year.

Sunray to Supply Alkylate

Sunray Oil Corporation has signed a contract with the Armed Forces Petroleum Purchasing agency to supply alkylate for blending into 115-145 grade aviation gasoline, according to an announcement by H. W. Manley, vice president and general manager of Sunray's manufacturing, sales, and pipe line department.

Sunray Oil Corporation is currently rehabilitating its World War II HF alkylation plant at its Sunray (Duncan), Oklahoma refinery for the primary purpose of manufacturing alkylates for the government. The remodeling work has been contracted by the Refinery Engineering Company of Tulsa, Oklahoma. The extensive modernization program includes all of the latest design features of the newest HF alkylation plants and involves capital expenditure of about $2,000,000.

When completed in March 1953, the Sunray alkylation unit is rated to produce 1500 bbl per day of light alkylate.

Monsanto to Make Phenol

Monsanto Chemical Company has now begun construction of a plant on an 86-acre site at nearby Avon, California, for the manufacture of phenol, it was announced here by Irving C. Smith, general manager of the company's Western Division.

The new plant, which is expected to be in operation by early 1954, will be jointly built and operated by Monsanto's Western and Organic Chemicals divisions. It will manufacture phenol by a process developed by the company.

PERSONALS

W. A. Schlueter, president of Refinery Supply Company of Tulsa, and vice president of Central Scientific Company, Chicago, was presented with a medal for helpful instrument service in the natural-gasoline industry at the Natural Gasoline Association of America meeting in Houston recently.

Schlueter's contribution to the standardization of testing methods in the petroleum industry dates back over 40 years when he helped develop the Saybolt chronometer, Saybolt viscosimeter, Tagliabue open cup flash and fire tester. Since that time he has patented many valuable items including the R. S. specific gravity gas balance, the AC-ME recording gravitometer, R. S. mercury purifier, R. S. dead weight tester, R. S. high-pressure consistometer, R. S. pressure hydrometer jar, and R. S. thermo plumb-bob thermometers.

R. A. Forsman has been transferred from the Cushing, Oklahoma, refinery to the Tulsa, Oklahoma, office, Deep Rock Oil Corporation. Forsman received a B. S. degree in petroleum engineering from Tulsa University in 1941. Following his graduation, Forsman was employed as a service engineer with an industrial engine manufacturer until 1946, with a three-year leave during the war. He joined Deep Rock in 1949 as assistant chief engineer in charge of maintenance and has worked at the Cushing refinery until his present transfer.

D. L. Yabroff, formerly on temporary assignment as manager of Shell Oil Company's manufacturing-research department, head office, New York, has rejoined Shell Development Company, Emeryville, California, as associate director of research. He is in charge of chemical products, replacing associate director **K. R. Edlund,** who has been appointed special assistant to president M. E. Spaght.

Stuart Mossom has been moved from Houston to Magnolia Petroleum Company's general offices in Dallas and made an assistant manager of the natural gas department. Mossom will be concerned with special problems regarding gas units operated by other companies in which Magnolia participates. In addition to these duties he will continue to be co-ordinator of off shore operations for the company's exploration division.

Harris Bateman, chief engineer of Cities Service Oil Company (Delaware) will soon join the Petroleum Administration for Defense in Washington as head of the materials section. During his absence **C. S. Mitchell,** in addition to his duties as manager of crude oil supply and transportation, will be the executive in charge of the engineering division.

Ben D. (Tex) Leuty of Bartlesville, Oklahoma, has been appointed assistant chief engineer of Cities Service.

W. T. Askew

J. S. Thompson

R. H. Clark

W. T. Askew has been named assistant manager of Sun Oil Company's refinery at Marcus Hook, Pennsylvania. Formerly superintendent of the refinery, Askew will be succeeded in that position by **John S. Thompson.** Thompson had been assistant superintendent in charge of the plant efficiency division.

Askew joined Sun Oil Company in 1931, immediately after graduating from Texas A. & M. with a degree in chemical engineering. He was appointed superintendent of the refinery in 1949.

Thompson joined Sun Oil Company in 1931. He later became superintendent in charge of cracking plants and in 1941 was named assistant superintendent of the refinery in charge of plant efficiency. He was graduated from Princeton University in 1927.

R. H. Clark has been appointed to be superintendent of the newly created separate settlement division of Phillips Petroleum Company, K. S. Adams, board chairman, and Paul Endacott, Phillips president, have announced. This division has been part of the contracts and settlement division of the company. Clark will report to the manager of the natural gasoline department, George P. Bunn, and the appointment is effective immediately. Clark began with the natural gasoline department of Phillips in 1921 and has been in settlements work continuously since that time.

Harold Bible

Harold Bible has been promoted to the newly created post of assistant manager of manufacturing according to J. B. Rogerson, manager of manufacturing of Lion Oil Company. Bible, who has been technical assistant to T. M. Martin since December 16, 1943, will assist Rogerson in the management of Lion Oil's growing manufacturing activities, which include an oil refinery and chemical plant at El Dorado (Arkansas) and a new chemical plant now under construction near New Orleans (Louisiana).

T. M. Martin, president, has named **Ralph Latimer,** who has been supervisor of the contract section of Lion's land department, to replace Bible with the title of administrative assistant to the president.

Joseph W. Darby and **John Moran,** operators at the Paulsboro, New Jersey, refinery of Socony-Vacuum Oil Company, Inc., were jointly awarded $3500 recently under the company's suggestion system. The suggestion, submitted separately by each of the two award winners, brought about a reduction in shutdown time and in loss of solvent used by the Paulsboro refinery's Duo Sol unit, which processes lubricating oils.

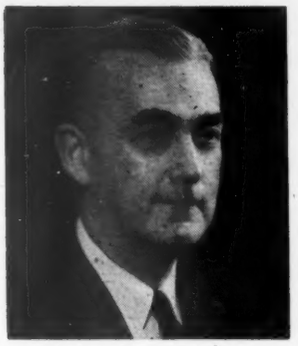
Dr. K. A. Smith was promoted to the post of director of the light oils division of Sinclair Research Laboratories, Inc., according to E. J. Martin, vice president and general manager.

Upon graduation from the University of Wisconsin in 1943, with a Bachelor of Science degree in chemical engineering, Smith began his career with Sinclair in its research and development department. One of his first assignments was in the operation of pilot plants, where he did much work during the war on the research and development of new aviation gasolines. Smith was also connected with the Process Design division of the research and development department. In 1946, he again took up his scholastic work at the University of Wisconsin. In 1948, he was awarded his PhD in chemical engineering, whereupon he returned to Sinclair research and development and was assigned to the light oils division. He holds membership in several scientific organizations, two of which are the American Institute of Chemical Engineers and the Alpha Chi Sigma.

The new position which Smith assumed will cover the direction of research and development work on processes and products in light oils.

M. P. Venema

M. D. Gilchrist



J. C. Raaen

R. E. Sutherland

M. P. Venema, formerly a vice president, Universal Oil Products Company, has been elected executive vice president. **M. D. Gilchrist** has been elected a vice president with responsibility for sales. **Colonel J. C. Raaen** was named a vice president, with responsibility for Universal's research and development laboratories, remaining as general manager. **R. E. Sutherland** was elected a vice president with responsibility for all engineering functions.

Edwin F. Nelson, formerly a vice president in charge of engineering has resigned to enter business in Superior, Wisconsin. Nelson will continue his association with Universal in a consulting capacity.

John R. Bates, formerly head of the chemical research and development department of Sun Oil Company has been appointed as technical adviser to the executive committee of Sun's board of directors, announces Robert G. Dunlop, president. Dr. Bates has resigned from the board of directors, and his administrative and operational responsibilities have been transferred to Dr. J. Bennett Hill, chemical research and development department director. Bates' new position will include process investigations in the petroleum and petrochemical fields and studies of market trends and possibilities in processes and products, in order to keep the directors informed of developments in the industry.

John C. Raaen, recently elevated to the post of chairman of the board of directors of Procon Incorporated, petroleum refinery construction firm of Chicago, has announced the election of officers at a board meeting held on August 4. **Carl B. Whyte,** formerly executive vice president, was made president. **A. G. Petkus** and **J. C. Reed** were elected vice presidents.

S. C. Taylor, Solvay Process Division, Allied Chemical and Dye Corporation, has been named president of the Houston Chemical Club. Other officers include: Vice president, **W. J. Bramblett,** Columbia-Southern Chemical Corporation; secretary-treasurer, **J. L. Pickens,** Mathieson Chemical Corporation; assistant secretary treasurer, **R. D. Shaw, Jr.,** Texas Chemical Division, McKesson and Robbins, Inc.

Directors are: **R. C. Collins,** Stauffer Chemical; **Ed R. Lett, Jr.,** General Chemical Division, Allied Chemical and Dye Corporation; **A. P. Jones,** Consolidated Chemical Industries, Inc.; **E. R. Scogin,** Shell Chemical; **G. A. Wilkinson,** Mallinckrodt Chemical Works; **S. C. Morian,** Dixie Chemical (retiring president), is an ex-officio member of the board of directors.

F. L. Martin

Ted C. Bodley

New Refining Company Will Build Texas Plant

Formation of Suntide Refining Company, with F. L. Martin as president and chief executive officer, and Ted C. Bodley as vice president and secretary, has been announced. The company will build a 30,000 bbl per day refinery at Corpus Christi, Texas, on a 134-acre plot owned by Sunray Oil Corporation of Tulsa, which turned the land over to Suntide. Sunray owns a controlling interest in the company, it is understood, and the financing was handled by Eastern investment firms led by Eastman, Dillon and Company of New York.

Other company officers are: E. T. Herndon, vice president and treasurer, representing an eastern investment company; and Frederick Bruenner, assistant secretary, also representing a firm interested in the financing. Company directors include Martin, Glenn Smith, Tulsa; E. T. Howell, Oklahoma City; E. T. Herndon and Lloyd Gilmour, New York City.

E. W. Patterson, formerly technical adviser at Sunray's Duncan, Oklahoma refinery is on the new staff as project engineer. Miss Betty Hunt, formerly executive secretary to F. L. Martin at Sunray, is executive assistant.

The refinery design and construction will get under way immediately it is understood, and is expected to be completed late in 1953.

You can maintain your required speed for the full period of the test with much less effort. Curtin centrifuges, proven world-wide, are heavy duty, rigidly constructed, and extremely simple in design. Illustrated bulletin, giving full details, available upon request.

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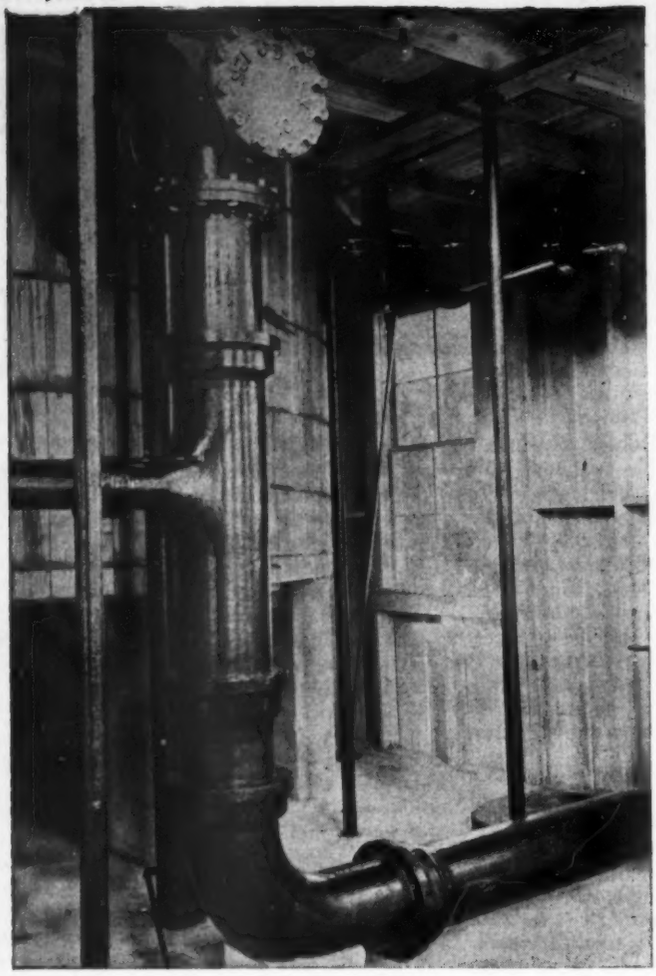
HOUSTON . . . NEW ORLEANS



DIRECT ROUTE TO LOWER PLANT MAINTENANCE

The direct and indirect expense of replacements of short-lived refinery pipe lines can be reduced, or avoided altogether, by the use of cast iron pipe. This has been proved by many refineries whose maintenance costs have been lowered by replacing other pipe materials with cast iron. A relatively low first-cost material, cast iron pipe is usually cheapest in the end, for many refinery applications, because of its stubborn resistance to corrosion. Available with bell-and-spigot, plain end and flanged, or with standardized mechanical joints.

Cast Iron Pipe Research Association, Thomas F. Wolfe, Engineer, 1015 Peoples Gas Bldg., Chicago 3, Illinois.

CAST IRON PIPE
FOR LONG LIFE AND ECONOMY

Personals

R. W. Parker

W. G. Miller

R. W. Parker has been appointed project manager in charge of all phases of design, field construction, and other activities directly related to the direction of the Australian Oil Refining Pety., Ltd., refinery at Kurnell, Australia. Parker joined Caltex in 1948 and was sent to Europe to supervise activities in refinery construction.

A. J. Herron has been appointed general manager of Australian Oil, in charge of operations of the new company. Herron joined The Texas Company in 1921 and in 1930 became assistant superintendent of the West Dallas refinery of Texaco, and in 1944 was transferred to The Bahrain Petroleum Company, Ltd., an affiliate of the California Texas Oil Company, Ltd.

W. G. Miller has been appointed project manager in charge of all phases of field construction, field designs, and other activities related to the erection of the refinery of Caltex (Philippines) Inc., at Batangas, Philippines. Miller joined Caltex in 1943 and was assigned to supervise the construction of extensive facilities in Bahrain for the manufacture of aviation gasoline.

L. D. Josephson has been selected for the post of refinery manager of Caltex (Philippines) Inc. He will be in direct charge of the operations of the new refinery. Former superintendent of personnel at Bahrain, Josephson joined Caltex in 1939. In 1945 he was made a general operating foreman at Bahrain, in charge of the fluid catalytic cracking unit, then, in 1947, he became assistant refinery superintendent at Bahrain.

Luther R. Hill, head of Process Designs, Inc., of Ridgewood, New Jersey, has been appointed consultant on catalytic processes by Houdry Process Corporation, announcement states. Hill is an authority on catalytic processing, graduate chemical engineer of the University of Texas, and has spent 25 years in various phases of the petroleum industry.

Luther R. Hill

J. F. Francis, superintendent of the Lone Star Producing Company's McElroy-Wilshire gasoline plant, Upton County, West Texas, is holding a safety award. In constructing the plant 50,000 man hours were worked without a disabling injury.

Control of Pipe Line Booster Stations

Maximum and safe pipe line throughput requires application of interlocked controls

J. PROCOPI*

TRANSITION from float tank operation to the closed line type of operation in recent years is a significant fact, observed by all men engaged in the field of transporting crude oil or refinery products through pipe lines. These men have recognized the advantages gained in refinery operation by keeping different crudes segregated. Different refinery products in pipe lines must, of course, be pumped separately. In the closed line system, where the whole pipe line functions as a unit, operators know that all pumping stations and sections of the line must generally pump at the same rate. Unless flows at each station are regulated automatically, it is difficult to maintain maximum throughput and at the same time guard against excessive discharge pressures or low suction pressures

In addition, *continuous* operation at required rates of crude oil or products flow is, of course, of vital concern to station operators. Every precaution is taken to assure against breakdown or failure of the pumps and their drivers.

Among the several critical operating factors, temperatures of motor windings, as well as of motor or pump bearings and glands, are some of the most important. Excessive temperatures can impair or permanently damage the insulation on motor windings, or cause undue wear of bearings to such an extent that a major overhaul of the pumping units is required. Not only is such work costly but it also causes the loss of much valuable pumping time.

Finally, automatic start and stop devices are widely used, with their application largely governed by local conditions. In general, these controls may be used to make or interrupt the starting circuit for automatic start or stop of electric motors, ground the magnetos for shutdown of ignition engines, or cut off the fuel supply for shutdown of either ignition or diesel units.

Maintaining Maximum Throughput

One solution to the problem of maintaining maximum throughput is the use of an automatic pressure controller on both the suction and discharge lines at each pumping station. In order that these controls do not limit maximum flow in normal operation, they are arranged to operate the same final control element (such as a diaphragm motor valve on the discharge line), throttling the flow *only* when the suction pressure drops to a predetermined minimum value, or when the discharge pressure rises to a predetermined maximum value. This function is provided in *one instrument*—such as the Brown *single pilot dual pressure controller* described below.

Suction and Discharge Pressure Controller

With a *single pilot dual pressure controller* and a suitable final control element, the following functions are provided:

(1) Records of both suction and discharge pressure on one circular chart to serve as a permanent log of 24 hr of operation.

(2) Independent adjustments for minimum suction and maximum discharge pressures by means of separate set point adjusting knobs in the instrument.

(3) Integral control bypass panel to permit manual control based upon either suction or discharge pressure, at the discretion of the station operator. (Particularly useful for bringing a pump unit into operation.)

(4) Gradual throttling control action, automatically, in the event that either the suction or discharge pressure approaches its preset limit—thereby protecting the pump from being starved for suction pressure or creating a discharge pressure exceeding the safe limit of the pipe line.

(5) Transfer of automatic control action smoothly from suction to discharge pressure, or vice versa, with no sudden flow changes to create undesirable pressure surges.

(6) Full-rated flow capacity of pumping station permitted during normal operation where suction and discharge pressures are within their preset limit ranges.

(7) Automatic adjustment of pump operation for variations in line pressure due to changes in pumping rates at preceding or following stations along the line. Hydraulic gradients between each station are "matched," even if one station is out of service.

These functions combine in general to afford easier operation of the station and more accurately controlled pressures, together with a greater average throughput than can be provided by manual operation.

The *single pilot dual pressure controller* can be employed in several ways, de-

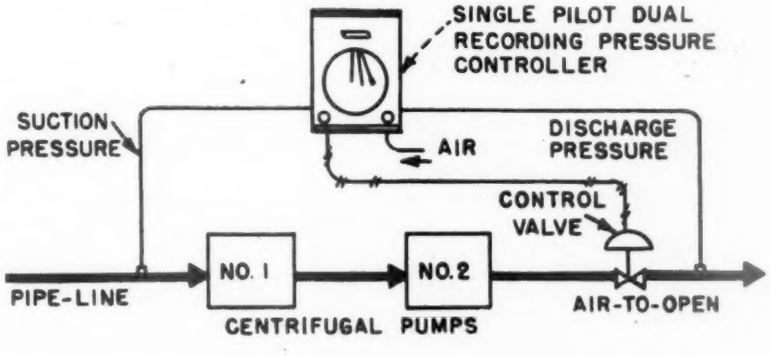


FIG. 1. Schematic diagram of interlocked pressure control system for centrifugal pump.

*Petroleum industry engineer, Minneapolis-Honeywell Regulator Company, industrial division.

EXCLUSIVE

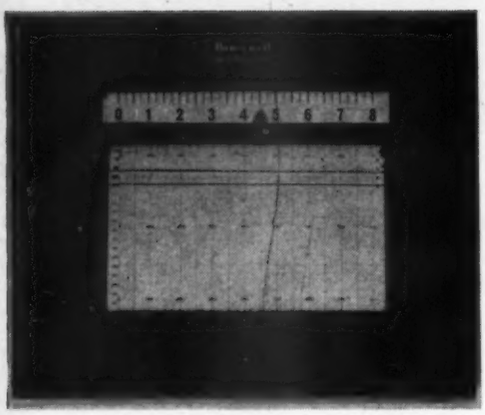


Fig. 2. Multi-point ElectroniK recorder for logging of motor and pump temperatures.

pending upon the type of pump and the manner in which it is controlled. As shown in Fig. 1, for example, it can be used: (1) with centrifugal pumps in series where a control valve is installed in the discharge line, and (2) with reciprocating pumps where individual control valves are installed in bypass lines around each but are operated by the same dual controller. In addition, the instrument can be incorporated in pumping systems that employ speed control—so long as the control element can be pneumatically operated.

Operation of Suction and Discharge Pressure Controller

When applied to centrifugal pumps, (Fig. 1), the pneumatic controller has pressure connections made to the suction and discharge sides of the pumping unit (a single pump or a series of two or more pumps). As shown in the diagram, the output control air from the instrument is connected to a diaphragm motor valve in the discharge line. This valve is of the air-to-open type, increasing its opening as control air from the instrument increases in pressure.

Within the instrument case are two separate proportional control units of the conventional design found in all Brown pneumatic controllers. One control unit serves to throttle the output control air to the valve if the suction pressure drops toward its limiting value; conversely, the second control unit serves to throttle the output control air to the valve if the discharge pressure rises toward its limiting value. The two control units, with separate flapper-and-nozzle assemblies, are connected in parallel to one pilot relay in the instrument so that either control unit can override the other and govern the control valve opening.

As an example of this system in operation, assume that one instrument control index is set at 30 psi for minimum suction pressure, and the other index is set at 750 psi for maximum discharge pressure. During pump operation, as long as the line pressure lies well within these limits, the control valve remains fully open, because output air pressure from the controller is at its maximum of about 20 psi. If the suction pressure now begins to fall, its control unit will begin to throttle output air to the valve as the pressure approaches the minimum set point.

While the above control action takes place, any build-up of the discharge pressure toward the maximum set point of the second control unit can cause further throttling of the control valve. The exact point at which control action starts with either control unit depends upon what is termed the *proportional band* adjustment of each control unit. In conjunction with the *manual reset* adjustment, the band adjustment could, for example, determine that throttling action would occur over a range of suction pressure from 200 psi down to 30 psi.

Safeguarding Against Excess Temperatures

Excess pump and motor bearing temperatures, pump seal or gland temperatures, and motor winding temperatures may be prevented by various temperature devices, such as: Mercoid capillary tube multiple contact temperature switches, or Fenwal snap action temperature switches that, directly or through relays, actuate alarms and shutdown relays and give pilot lamp indication of excessive operating temperatures. The following integrated detection and alarm system using thermocouples or resistance thermometer bulbs in conjunction with multiple point scanning electronic recorders and multiple selective alarm contacts, is one method of obtaining both a continuing record of unit temperatures and alarm and shutdown in the event of excessive temperatures.

ElectroniK Multipoint Recorders

The operation of such a system can best be described by referring to a hypothetical case. Assume, for example, that a station has three centrifugal pumping units in series and that the maximum safe operating temperatures in the electric motors are as follows:

Motor windings, 240 F (two points).
Pump and motor bearings, 175 F (four points, outboard and inboard).
Pump glands, 150 F (two points, outboard and inboard).
Pump case, 125 F (one point).

With the three pumps and motors, therefore, a total of 27 temperature records are required (9 on each pump unit). Furthermore, four different alarm points are needed; all but excessive motor winding temperature should cause shutdown of the pumping units. There requirements can be met with two *ElectroniK* recorders with alarm switches.

Before the system is put in operation, alarm switches in the recorders are set at the four maximum allowable temperatures, and connections are made to the thermocouples or resistance thermometer bulbs so that all temperature points associated with one alarm point are wired through the selector switch for this alarm (Fig. 3).

Alarm Switch Operation

The switch moves in time with the thermocouple selector switch, as the recorder is successively connected to the thermocouples or resistance bulbs. This method is employed so that each selected alarm point is active only on certain records. As illustrated, for example, alarm switch *A* might be set for 240 F for records 1, 2, and 3 (motor windings); while alarm switch *B* is set for 175 F for records 4, 5, and 6 (pump or motor bearings).

In the diagram, the alarm selector switch is shown connecting switch *A* with the relay for temperature point No. 1. If this temperature exceeds the alarm set point, relay No. 1 is energized to close the alarm circuit and will maintain this circuit through its "holding-in" contact (a second contact on switch *A* can be employed to automatically de-energize this alarm circuit on the next cycle of measurement — provided the temperature has dropped below the alarm set point). A timing switch is included in the circuit to close just before the instrument is ready to print a specific point, thus preventing any false switch action between points.

From Fig. 3, it will be seen that even though temperature points 1, 2, and 3 may be higher than the 175 F set point for alarm switch *B* (meaning that switch *B* alarm contact would be closed), the alarm relays for switch *B* can not be energized because the alarm selector switch is on point No. 1. Also from the diagram, it can be seen that any desired point on the recorder can be connected in with any alarm switch; for example, a simple change of wiring in the circuit illustrated would permit point No. 6 to be disconnected from switch *B* circuit and connected in switch *A* circuit. Thus, temperature points can be spaced in the recorder cycle to be checked in any desired order.

Furthermore, if one point (such as the pump case) is considered more critical and it is desired to check it two or more times during the recorder cycle of operation, this can be done simply by wiring in the thermocouple for this point at equally spaced intervals in the recorder cycle—say, for example, every 20 sec on an 80-sec cycle of operation (5 sec per point is standard for the recorder). In this example, the pump case temperature would then be checked every fourth point.

In operation, if the temperature of any point exceeds the alarm setting for that point, an electric signal light, howler, horn, or any other type of alarm can be energized to warn the operator. The recorder continues to check and record other points. On its next cycle of meas-

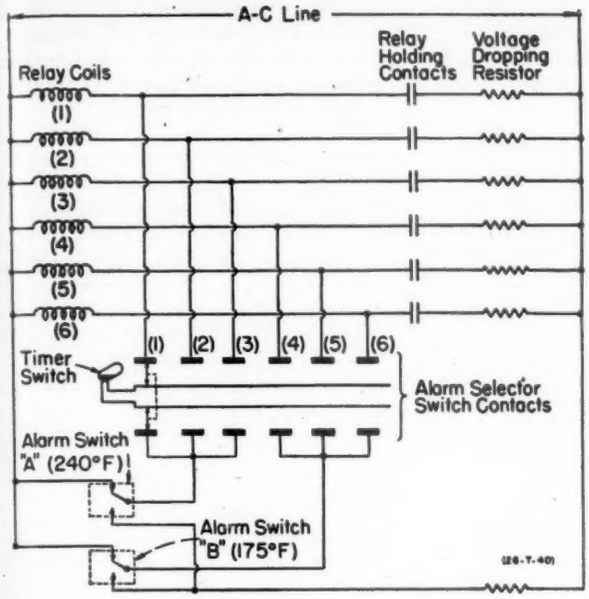
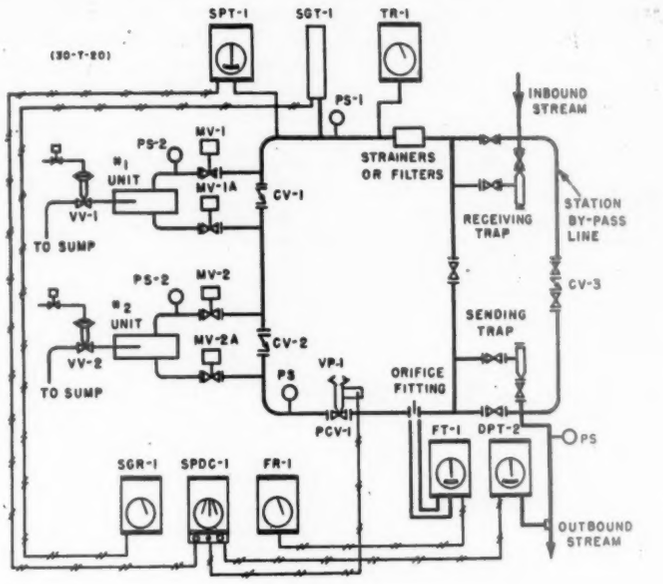


FIG. 3. Schematic diagram of alarm selector circuit in multi-point ElectroniK recorder-logger-monitor.



Legend:

SPT-1	Suction pressure transmitter	SGT-1	Specific gravity transmitter
DPT-1	Discharge pressure transmitter	SGR-1	Specific gravity recorder
SDPC-1	Single pilot dual pressure controller	FT-1	Flow transmitter
TR-1	Temperature recorder	FR-1	Flow recorder
		VP-1	Valve positioner
		PCV-1	Pressure control valve
		PS	Pressure switch

FIG. 4. Typical pumping station control system.

urement, the instrument can be arranged to de-energize the alarm point previously energized, provided the excessive temperature has dropped below the alarm set point; or it can be arranged so that manual reset of the energized alarm is required.

Due consideration must be made before selection of any of the methods of temperature detection described, as the shutdown relays must be interlocked with the switchgear. Where few detection points are required the cost per point of a multiple point recorder will be considerably higher than that of the mercury or snap action switch.

Startup and Shutdown

A typical booster pump startup and shutdown sequence for electric motor-driven centrifugal pumps is as follows:

With the typical booster station out of service either because of shutdown of stations on the pipe line either upstream or downstream, or because of line throughput requirements not warranting the operation of the booster station, the station is bypassed through check valve *CV-3* (Fig. 4). Provided sufficient suction pressure is available at the station suction (usually 25-40 psi), pressure switch *PS-3* will make contact, thus permitting the pumping units to be started at the will of the station operator.

The automatic starting sequence, controlled from a desk in the control room in most modern stations, permits the station operator to place the pump unit on stream while adjusting the suction-discharge controller to the settings required. A typical starting procedure is as follows:

(a) The unit start button is depressed at the control desk.

(b) Pump suction valve *MV-1* opens.

(c) When open limit switch of *MV-1* makes contact, and if *PS-2* is closed, an auxiliary relay in the pump starting circuit will close, thus starting the pump.

(d) The solenoid pilot vent valve *VV-1* will vent vapors from the pump case and allow sufficient fluid flow through the pump case to prevent excessive pump case temperatures.

(e) When pump has come up to speed, *MV-1A* will start to open, and when partial flow is established through this valve an intermediate limit switch will close the pump case vent valve *VV-1*.

(f) Discharge valve limit switch indicates full open and starting sequence is complete.

Timing sequence checks are usually incorporated into the starting sequence controls to return the unit to the normal shutdown condition in the event that the sequence is not completed within a predetermined time due to improper functioning of valves or electrical equipment.

To stop No. 1 pump, the stop button is depressed at the control desk, an auxiliary contact in the motor starter

FIG. 5. Differential converter.

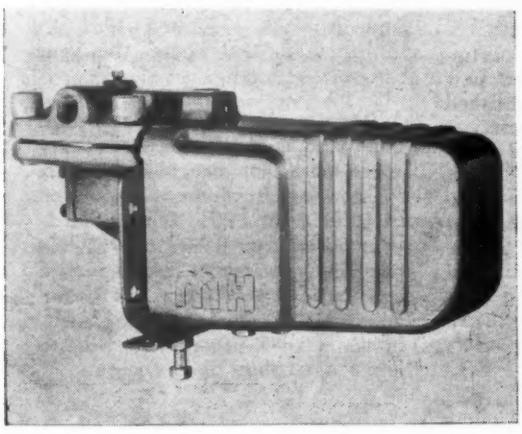
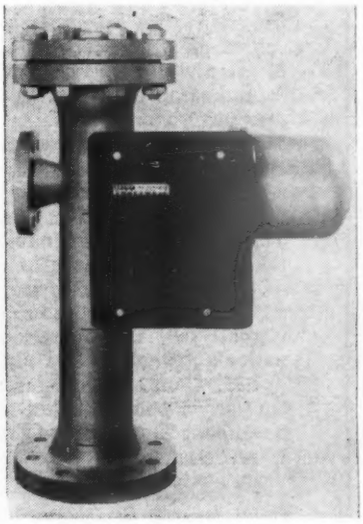


FIG. 6. Specific gravity transmitter.



drops out stopping the motor. Discharge valve *MV-1A* and suction valve *MV-1* close, and solenoid pilot vent valve *VV-1* opens, thus taking No. 1 pumping unit off the line. By a similar push-button arrangement, the second pump can be placed in operation, and either or both pumps can be shut down.

Pilot lamps (for indicating the position of all motorized valves), off and on pilot lamps (for the main motors), and lamps for high bearing, seal, and pump case temperatures, low suction pressures, and other protective functions are usually incorporated on the station control desk.

Additional Safety Devices

In addition to the use of temperature detecting devices for safeguarding pump and motor temperatures, pressure switches are installed as safety devices in several critical locations as illustrated. Low suction pressure switches (*PS-1* and *PS-2*) are set to close their contacts simultaneously, when the suction pressure decreases below 10 psi, resulting in shutting down of No. 1 and No. 2 pumps and sounding an alarm. The circuits remain closed until the suction pressure increases to a value of 40 psi. This wide pressure differential setting prevents operation of *PS-1* and *2* on minor variations of pressure with this range.

Similarly, pressure switches may be installed to shut down the pump and sound alarms when the suction pressure exceeds a preset maximum, or when outbound pressures fall below or exceed preset values and pressure or float switches may be used to provide alarm or shutdown in the event of seal failure or excess gland leakage.

Other Station Instrumentation

Pressure transmission and transmitters. There has been a recent trend toward pneumatic and electrical transmission of pressures and flow from points on the station piping to indicating, recording, and control instruments situated in a central control room. This has been done primarily to eliminate the hazards of bringing lines carrying highly inflammable liquids into the control room where a leak in piping fittings, Bourdon tubes, or instruments would endanger the safety of the station.

Conventional pneumatic indicating or non-indicating pressure transmitters with an output of 3 to 15 or 17 psi air have been used in conjunction with pressure gages designed to operate at 3 to 15 or 17 psi but having scales reading 0 to 150 psi or 0 to 1200 psi or other convenient ranges.

More recently, Baldwin strain gage pressure cells have been installed that, when used with electrical amplification, provide indication of pressures on conventional electrical meters having scales calibrated in psi.

Flow and temperature instruments. Flow instruments, either the mercury manometer or *differential converter* (mercuryless) type, play an important role in pump station operation. If a major leak occurs downstream of the pump station, the flow meter will indicate an increase in flow but the discharge pressure pen on the single pilot dual controller will show a pressure dip. This will indicate to the alert station operator that a leak or some other abnormal condition has occurred in the pipe line downstream of the station. Similarly, an increase in station discharge pressure without a corresponding increase in outbound flow indicates a partially blocked condition in the main line that may, for example, be caused by a scraper that has become stuck in the line.

Temperature recorders are used where a record of pipe line flowing temperatures is required and is particularly useful in conjunction with metering equipment.

Specific gravity transmitters and recorders. Indication of specific gravity of both products and crudes to detect batch changes is extremely important where fluid is taken from the main line into tankage at pump stations and terminals. An experimental installation is being made using a displacement type liquid level transmitter operating with displacer chamber full of fluid and sensing fluid specific gravity changes by means of variation in the buoyancy of the displacer. It is believed that this type of unit will provide the ruggedness and durability required for this type of instrument at a cost 25 to 30 per cent below more elaborate methods of determining specific gravities. * * *

AGA Issues New Edition of "Gas Facts"

The American Gas Association reports that total assets of the nation's gas distribution and pipe line industry at the end of 1951 amounted to 10.65 billion dollars, an increase of 1.35 billion dollars over total assets of the industry a year earlier. A considerable part of this increase in assets was accounted for by the continuing growth of the nation's system of gathering transmission and distribution pipe line mileage. At the end of 1951 there were 406,550 miles of gas pipe line in the United States, an increase of 19,080 miles over the previous year.

These facts, and many other pertinent data are disclosed in the new edition of "Gas Facts" just published by the American Gas Association. This yearbook of gas industry statistics is compiled by the AGA Bureau of Statistics from information gathered from companies representing virtually all the operations of the nation's gas utility and pipe line industry. Under basic operating data such as customers, sales, and revenues, about 95 per cent of the industry is represented.

A number of additional statistics have been included in the 1951 edition of "Gas Facts." These include the initial presentation of basic gas statistics pertaining to Hawaii and Puerto Rico. Also published are the statistics developed by the United States Bureau of Mines relating to the consumption of liquefied petroleum gases in liquid form, by state and type of use. Data compiled by the Petroleum Administration for Defense pertaining to steel and other materials used by the gas utility industry in its vast construction program between 1949 and 1951 are published in "Gas Facts" this year.

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Despite shortages of steel and other vital materials, the gas industry spent more than one billion dollars for new construction and expansion of facilities in 1951. During the 5-year period from 1946 to 1950, the gas utility companies and pipe line companies invested nearly 4 billion dollars for new plants and equipment. In the next 5 years, they plan to invest 4½ billion dollars more.

Another new table in the gas industry's statistical yearbook contrasts the number of residential gas utility customers using gas for house-heating, annually since 1949, with the expected number of additional users to be served during each of the next three years. Included again are the tables of composite industry-wide income statements and balance sheets for each year since 1937. These data proved of such interest to users of AGA statistics that interim industry income statements are now published as part of AGA's "Quarterly Report of Utility Gas Sales."

"Gas Facts" has been prepared under the general sponsorship of the AGA Committee on Economics and the more immediate direction of the Subcommittee on Statistics. These groups have been responsible for policy decisions regarding the type of material collected and published and the methods of presentation. Copies of "Gas Facts" may be obtained for a nominal amount ($1.00 per copy) from the Bureau of Statistics at the American Gas Association, 420 Lexington Avenue, New York 17.

From Quiriquire field, sited on its rugged, uneven terrain against mountainous background, the flow of natural gas heads for the refinery at Caripito.

PHOTOS COURTESY OF CREOLE.

Venezuelan Line Serves Twofold Purpose

Aids in greater conservation of Quiriquire field gas, which, utilized as fuel for Caripito refinery, releases fuel oil to market

HARRY CHAPIN PLUMMER

BEFORE the close of the first half of 1952, the Venezuela petroleum industry witnessed the completion and functioning of a six-year, $1,000,000 oil-gas switching project whereby 1400 bbl of fuel oil consumed daily in the refinery and power plant at Carapito, have been saved for overseas marketing and replaced by 11,000,000 cu ft of natural gas from wells several miles from the refinery site. Already the new fuel feed system has gained the regional nickname of "The Bent Inch," because the gas-gathering lines, consisting of approximately 4.6 kilometers of 12-in. pipe and 1 kilometer of 8-in., extend over a terrain so rugged that there is seldom a joint that is not bent in one direction or another. Thus another significant step has been realized in the industrial utilization of natural gas in Venezuela.

The project was conceived and preliminary investigations undertaken by the gas group of the petroleum engineer section of the Creole Petroleum Corporation in Caracas and further developed and executed by the field men in the Quiriquire oil and gas area. Quiriquire district engineers have had direct supervision over the construction of all phases of the project, with the exception of the Caripito Refinery conversion.

Original surveys and studies of the desirability of substituting gas for fuel oil were made in 1946, but due to inability to obtain the necessary material, the work was deferred. In June 1951, material was on hand and conditions were favorable for carrying on the job.

The work may be separated into four phases: (1) revision of existing and construction of new, gas gathering lines from field flow stations to the compressor plant; (2) modification of existing compressor plant facilities, including cylinder changes, to provide for gas transmission service in addition to pressure maintenance in the Quiriquire field; (3) construction of a new oil transmission pipe line and conversion of present oil lines to gas transmission service, and (4) conversion of oil-burning equipment in the refinery and electric plant to gas operation.

The original compressor plant consisted of six 600-hp electric-motor-driven, balanced-opposed reciprocating compressors, each compressor having two double-acting cylinders for compressing gas. The plant was originally designed to compress 10,000,000 cu ft of gas a day from zero psig to approximately 1000 psig in three stages.

By revising and constructing new gas

EXCLUSIVE

Caripito refinery of Creole Petroleum Corporation, where natural gas is utilized as fuel, replacing 1400 bbl of fuel oil heretofore consumed daily.

PHOTOS COURTESY OF CREOLE.

gathering lines, and changing compressor cylinders, it was possible to increase plant suction pressure from zero psig to 20 psig, thereby taking full advantage of pressures available at the separators. With such increase in suction pressure, by reducing the size of the first stage compressor cylinders, and redistributing the six compressors among the three stages, the total capacity of the plant was increased to handle 25,800,000 cu ft in the first stage, with only a small reduction in capacity of the second and third stages. That, of course, required extensive revision of the compressor plant piping.

Calculation of pressure drops indicated that the first stage compressor would be required to discharge at approximately 110 psig to assure a terminal pressure of 50 psig at Caripito. The average stream day requirements of fuel gas to Caripito, based on the Btu equivalent of gas vs. fuel oil, are 13,000,000 cu ft per day, while the maximum stream day requirements are 16,900,000 cu ft per day. In addition 800,000 cu ft a day will be used for fuel by the Quiriquire Camp. The remaining capacity of 8,100,000 cu ft a day is available for injection.

In order to compress these volumes, the cylinders of the two first stage compressors and two of the second stage compressors were changed to operate at the new first stage suction and discharge pressures of 20 to 110 psig. This allowed sufficient capacity in the first stage to operate only three first stage compressors on a normal stream day, leaving one compressor available for standby service most of the time. The remaining two compressors, originally operating as the third stage, were separated.

Two of the cylinders removed from the second stage compressors were installed on one of the third stage compressors and put in second stage service. That compressor will take suction from the first stage discharge at approximately 110 psig and discharge to the third stage at approximately 335 psig. Except for minor changes in piping, the remaining third stage compressor will remain as originaly installed.

Because of the high concentration of CO_2 produced by Quiriquire field, much of the original piping had to be replaced because of corrosion damage. In order to reduce such corrosion and to handle the increased volume of gas compressed, one new first stage scrubber equipped with demisting section was added and line scrubbers attached to the outlet of the two existing first stage scrubbers. Another line scrubber was installed in the gas transmission line to Caripito, to remove moisture condensed when the first stage gas is cooled. Also, second and third stage scrubbers were replaced by new scrubbers with demisting sections. Further, to safeguard against corrosion, it is planned to inject an inhibiting agent into the gas.

At the present time Quiriquire crude oil is pumped to Caripito refinery through a system of approximately 5 km (3⅛ miles) of 16-in. pipe, previously laid to increase the capacity of the crude transmission pipe line, two 10-in. lines in parallel approximately 8.5 km (5.32 miles) long, and 2.5 km (1.56 miles) of 16-in pipe terminating at the Caripito refinery.

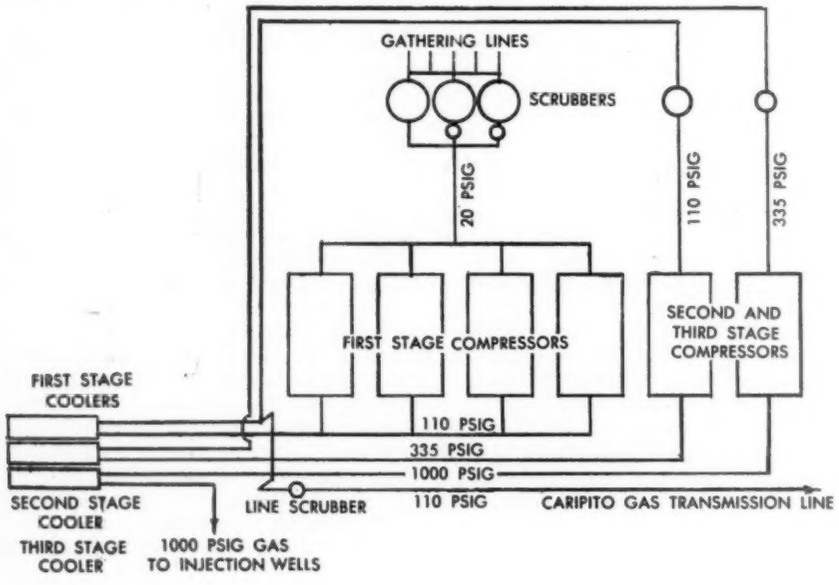
From studies made in conjunction with the gas transmission project, it was decided to retain the 5 km (3⅛ miles) of 16-in. for crude oil service and replace the two 10-in. lines with a larger line, in order to decrease large crude oil pumping power requirements caused by the increasing gravity of the Quiriquire crude. For that purpose approximately 11 km (6⅞ miles) of 20-in. line were laid from termination of the 16-in. line to the Caripito refinery.

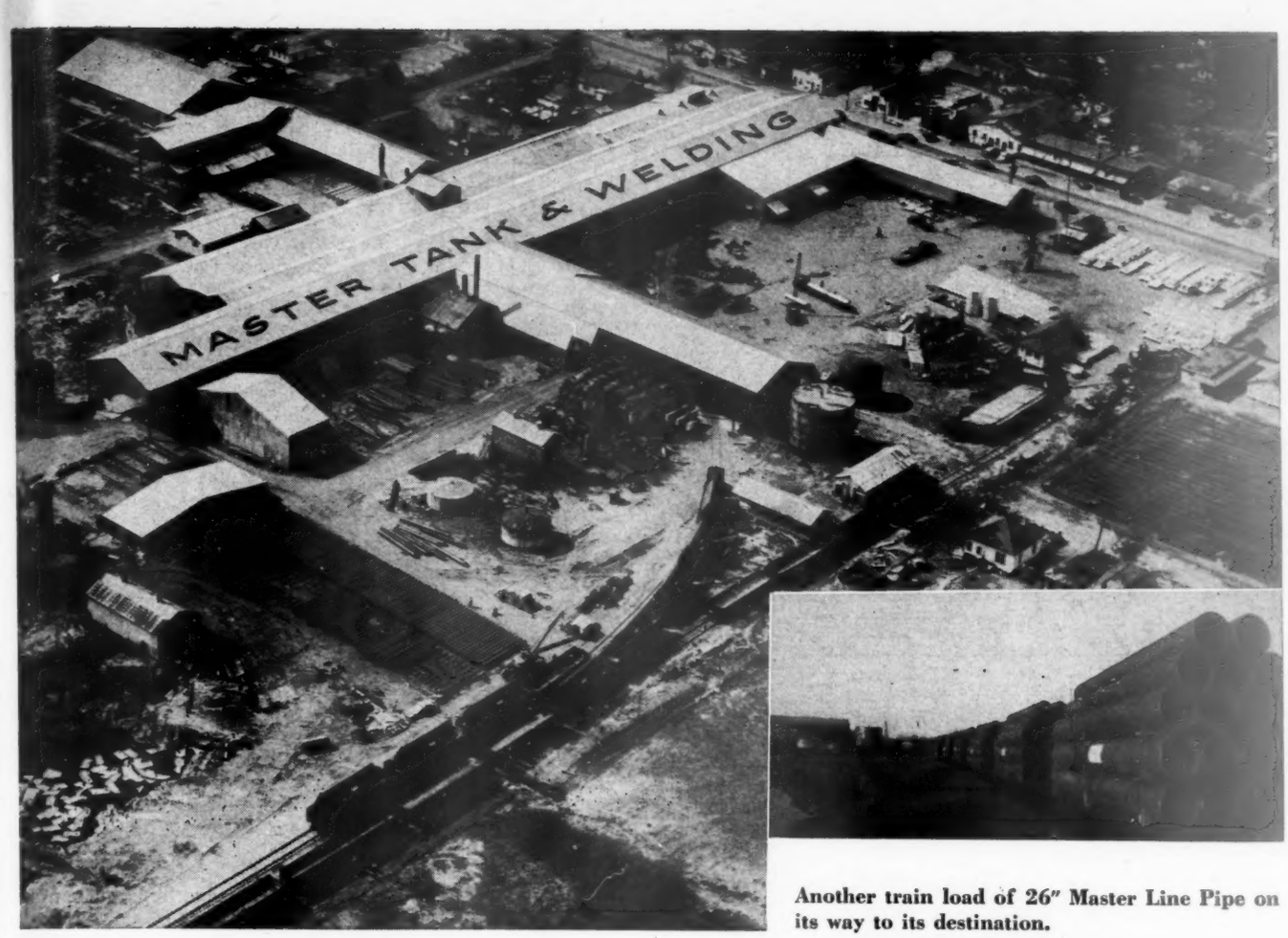
The gas transmission line from the compressor plant consists of approximately 3.5 km (2.18 miles) of 12-in. line, which will join the two 10-in. lines to be freed from crude oil service by the new 20-in. line and the 16-in. line now in crude oil service.

Quiriquire is a low pressure field. Few wells of the area can produce solely by natural gas pressure. The greater part of them have to rely upon artificial lift by pump. In the event that Creole engineers establish with certainty that they can contribute signally to prolongation of the life of the field and to increase of its production, Creole will be disposed to invest new and appreciable sums to bring to reality new projects for the maintenance of gas pressure. Meanwhile, the Quiriquire-Caripito gas pipe line will aid in the utilization approximately a third of the gas now produced.

Creole has utilized natural gas in increasing volume through the years. In 1945, 40,000,000 cu ft a day were consumed; by the end of 1950 that figure had risen to approximately 90,000,000.

Schematic diagram of Quiriquire compressor plant.





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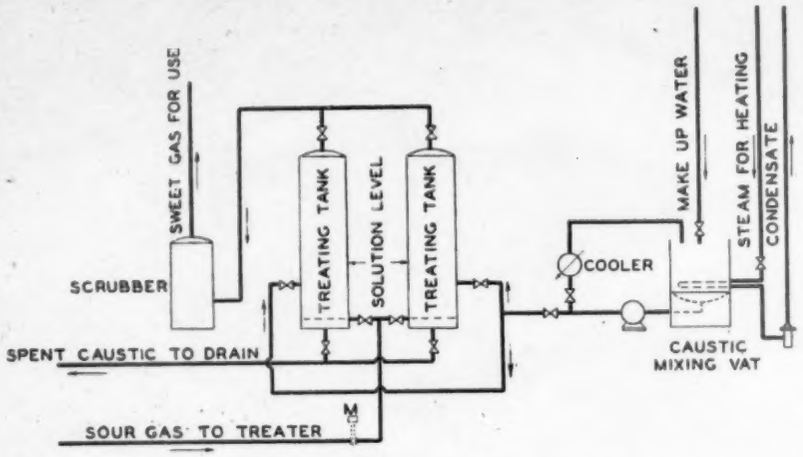


FIG. 1. Flow diagram of a caustic gas treater.

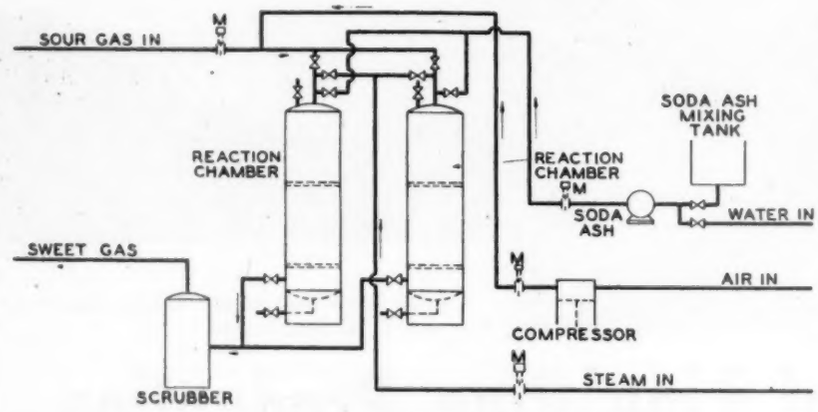


FIG. 2. Flow diagram of an iron oxide gas treater.

Desulfurization and Dehydration of Natural Gas†

Processes whereby sour and wet natural gas is made acceptable for pipe line sale

LEROY CULBERTSON and J. S. CONNORS*

THE markets for natural gas have expanded very rapidly during the last two decades. It used to be that the presence of hydrogen sulfide in a large percentage of the gas reserves limited the principal use for sour gas to the production of carbon black. As the carbon black companies could supply the demand for carbon black with only a fraction of the sour gas available, it was necessary to flare much sour gas in the course of producing oil. Many sour gas fields were left undeveloped due to the lack of markets. The development of methods by which hydrogen sulfide could be extracted from gas efficiently and economically to provide a suitable commodity for the light and fuel market and other sweet gas uses has been slow and expensive, but successful. The first portion of this paper will be devoted to the desulfurization of natural gas.

The second portion of the paper covers the two main commercial processes of dehydration for prevention of hydrate formation. The gas industry early learned that under the proper temperature and pressure conditions a gas pipe line or regulator will suffer a stoppage due to hydrates unless the water content of the gas is reduced.

Gas Desulfurization

Treating of gas to remove hydrogen sulfide and/or carbon dioxide has been practiced for many years. To date it has not been economically feasible to remove those impurities by distillation from natural gas used for fuel. Various chemical processes, many of which have been patented, have been employed for the purpose, however. Table 1 shows a partial list of the chemical processes for gas desulfurization that have been used on a commercial scale. In general, the chemical processes may be classified as either batch or regenerative.

The well-known caustic soda and lime slurry processes are typical of the batch type operations. Generally, they are not used in large scale operation due to the high reagent cost and the serious problem of disposing of the sulfides produced as end products of the reaction. A flow sketch of a caustic soda treater is shown in Fig. 1.

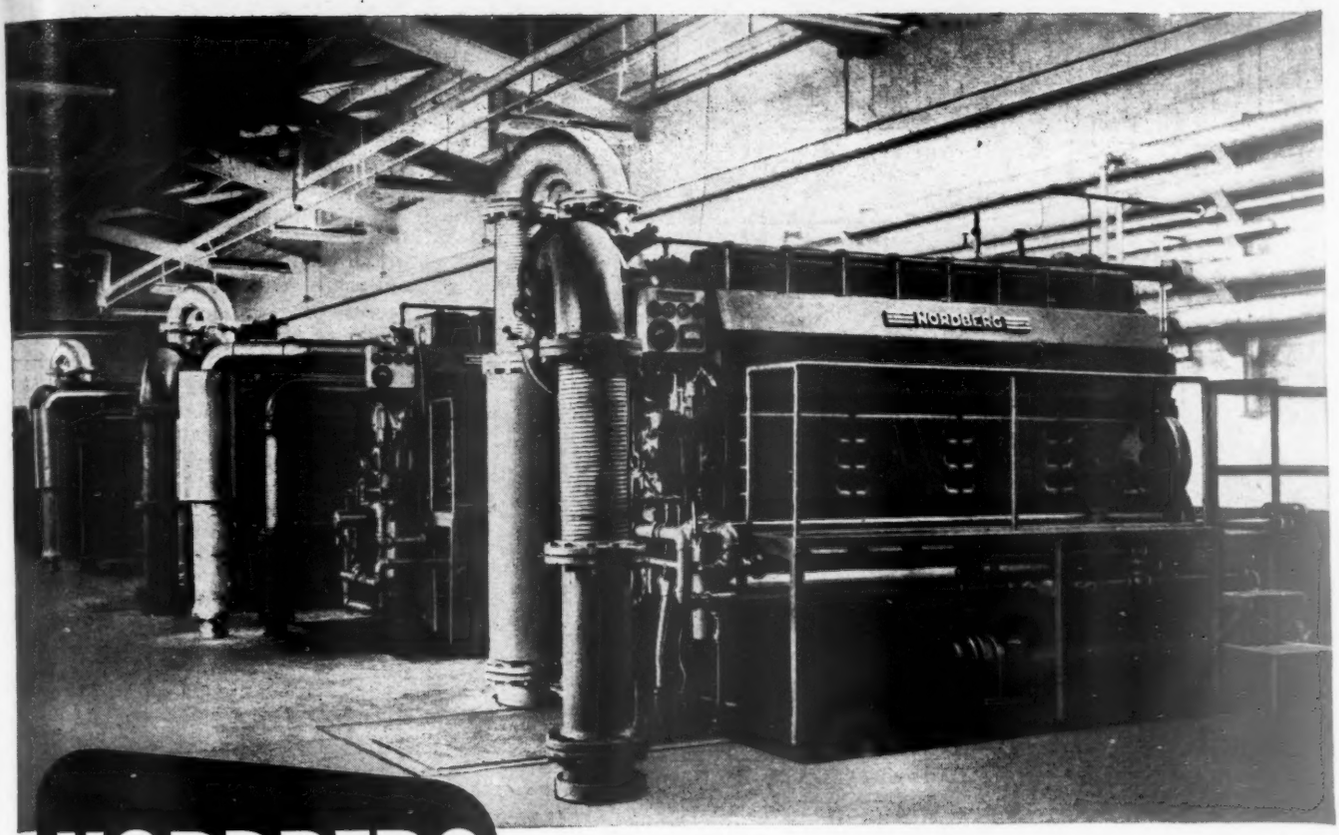
The modified iron oxide process, in which wood shavings impregnated with iron oxide are placed on trays inside a pressure vessel and the gas is passed downward through the beds, is applicable in cases where both the gas volumes and the hydrogen sulfide content thereof

TABLE 1—Chemical processes for hydrogen sulfide removal.

1. Caustic soda: $2\ NaOH + H_2S \rightarrow 2\ H_2O + Na_2S$.
2. Lime: $Ca(OH)_2 + H_2S \rightarrow CaS + 2\ H_2O$.
3. Iron oxide: $FeO + H_2S \rightarrow FeS + H_2O$; $FeS + \frac{1}{2}\ O_2 \rightarrow FeO + S$. (Second reaction produced by air blowing.)
4. Seaboard $Na_2CO_3 + H_2S \leftrightarrow NaHCO_3 + NaHS$. (Reaction reversed by air blowing.)
5. Vacuum carbonate $Na_2CO_3 + H_2S \leftrightarrow NaHCO_3 + NaHS$. (Reaction reversed by vacuum steaming.)
6. Thylox: $Na_4As_2S_2O_2 + H_2S \rightarrow Na_4As_2S_6O + H_2O$; $Na_4As_2S_6O + \frac{1}{2}\ O_2 \rightarrow Na_4As_2S_2O_2 + S$. (Second reaction produced by air blowing.)
7. Ferrox: $Na_2CO_3 + H_2S \rightarrow NaHS + NaHCO_3$; $Fe_2O_3 + 3\ H_2S \rightarrow Fe_2S_3 + 3\ H_2O$; $NaHS + NaHCO_3 + 2\ O_2 + Fe_2S_3 \rightarrow Na_2CO_3 + Fe_2O_3 + H_2O + 4\ S$. (Last reaction produced by air blowing.)
8. Nickel: Similar to Ferrox but nickel substituted for iron.
9. Girbotol: $2\ RNH_2 + H_2S \leftrightarrow (RNH_3)_2S$. (Reaction reversed by steaming.) R = organic radical.
10. Phosphate: $K_3PO_4 + H_2S \leftrightarrow KHS + K_2HPO_4$. (Reaction reversed by steaming.)
11. Phenolate: $C_6H_5ONa + H_2S \leftrightarrow NaHS + C_6H_5OH$. (Reaction reversed by steaming.)
12. Alkacid: $RCHNH_2COONa + H_2S \leftrightarrow RCHNH_2COOH + NaHS$. (Reaction reversed by steaming.) R = organic radical.
13. Houdry: $NiO + H_2S \rightarrow NiS + H_2O$; $NiS + 1\text{-}1/2O_2 \rightarrow NiO + SO_2$. (Second reaction produced by air blowing.)
14. Bichromate-zinc Sulfate: $ZnSO_4 + Na_2CR_2O_7 + 4\ H_2S \rightarrow ZnS + Na_2SO_4 + 2\ Cr(OH)_3 + 3\ S + H_2O$.
15. Potassium Permanganate: $2KMnO_4 + 3H_2S \rightarrow 3S + 2\ MnO_2 + 2\ KOH + 2H_2O$.

†Presented before Fourth Oil Recovery Conference, Texas Petroleum Research Committee, University of Texas, Austin, May 8 and 9, 1952.

*Phillips Petroleum Company.



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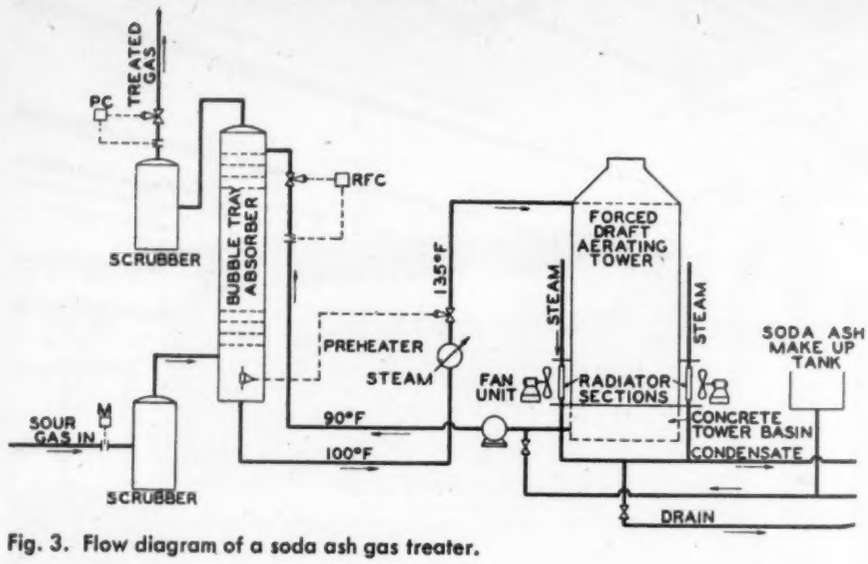

Fig. 3. Flow diagram of a soda ash gas treater.

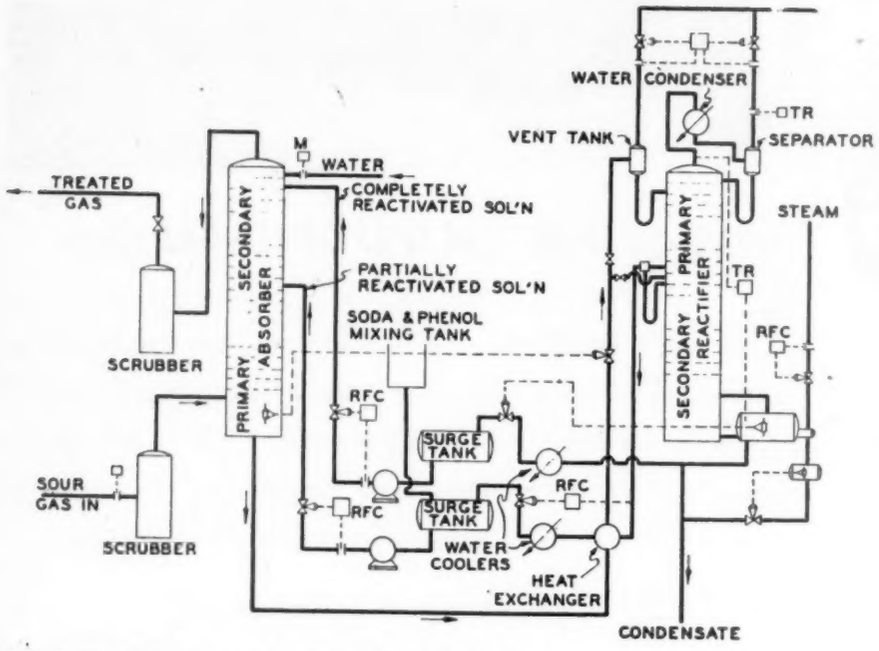

FIG. 4. Flow diagram of two-stage phenolate treater.

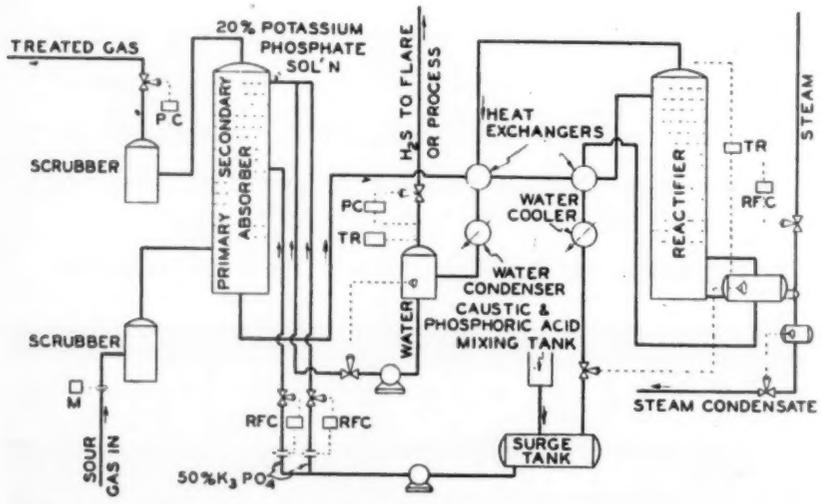

FIG. 5. Flow diagram—phosphate gas treater.

are low. A flow sketch of this process is shown in Fig. 2. This process has an advantage over the caustic or lime slurry process in that the treating reagent is not appreciably affected by the quantity of carbon dioxide present in the gas. If oxygen is present in the gas to be purified by this method it is possible to obtain more than 100 per cent conversion of the iron oxide content of the original sponge to iron sulfide (Fe_2S_3). This process or modifications thereof has been used for years by the manufactured gas industry.

In the purification of large volumes of natural gas containing appreciable concentrations of hydrogen sulfide, the regenerative processes are usually employed. The processes that have enjoyed the greatest commercial success in this country have been the soda ash, phenolate, tripotassium phosphate, and aqueous amine.

All employ the cycle of absorption and stripping but differ in the absorption and stripping media and in the degree of gas purity that can be obtained in practical operation. The development of the regenerative cycle gas treaters has progressed today to the point where the producer of sour gas can compete after treating with the producer of sweet gas for the pipe line market, both on a price and a quality basis. The soda ash process, Fig. 3, was the pioneer of the cyclic process treaters. The phenolate process is shown in Fig. 4 and the tripotassium phosphate in Fig. 5.

As the aqueous amine process, shown in Fig. 6, is the most widely used at the present time, detailed discussion of desulfurization by the cyclic processes will be limited to this process only. In the early stages of development, the preferred extractive agents were 50 per cent water solutions of either diethanolamine or triethanolamine. Later development has disclosed that the more preferable extractive agents are usually 10-15 per cent solution of monoethanolamine or 20-30 per cent solutions of diethanolamine in water.

In cases where the gas to be purified contains no carbonyl sulfide (COS) the more highly active monoethanolamine solutions are usually employed and the hydrogen sulfide content of the treated gas can readily be reduced to less than 0.25 grains per 100 cu ft. If desired, the hydrogen sulfide content can be reduced to below 0.05 grains per 100 cu ft. When carbonyl sulfide is present, however, solutions of diethanolamine must be used because carbonyl sulfide reacts with the primary amine forming a stable compound that cannot be regenerated. Gas treated by aqueous solutions of diethanolamine will seldom have a hydrogen sulfide content of less than 0.5 grains per 100 cu ft.

Operation of the amine process is based upon the fact that water solutions of the aliphatic alkanolamines have a strong affinity for acid gases such as hydrogen sulfide and carbon dioxide at approximately atmospheric temperatures (80-100 F), and that at slightly elevated temperatures (230-240 F) this affinity decreases rapidly with resulting release

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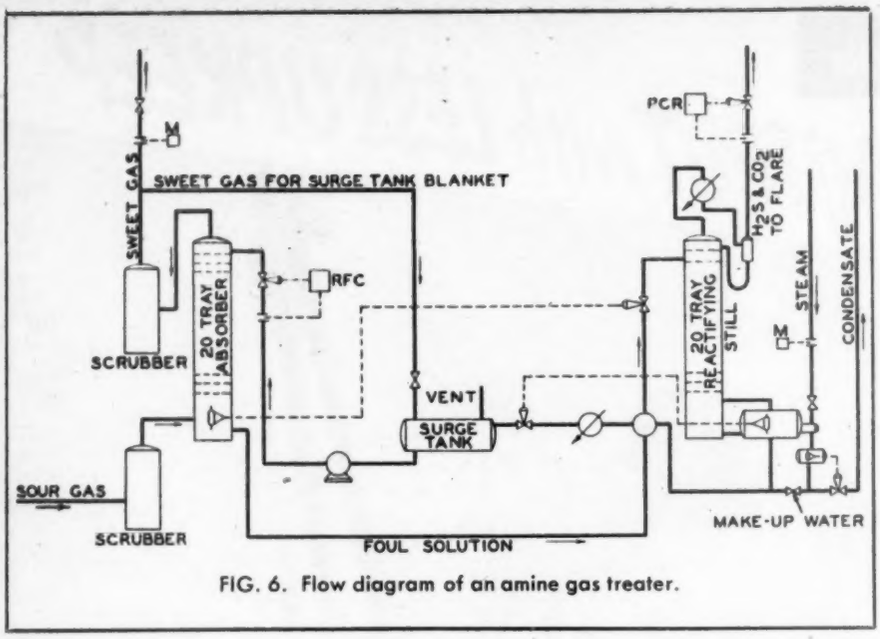

FIG. 6. Flow diagram of an amine gas treater.

of such gases from solution. This affinity is actually a reversible chemical reaction in which the chemical bonds are so loosely attached that the process behavior is similar to that of absorption. It is believed that this reaction can be expressed by the following equations:

$$(1)\quad 2\ RNH_2 + H_2S \overset{100\ F}{\underset{240\ F}{\longleftrightarrow}} (RNH_2)_2 \cdot H_2S$$

$$(2)\quad 2\ RNH_2 + CO_2 + H_2O \overset{120\ F}{\underset{300\ F}{\longleftrightarrow}} (RNH_2)_2 \cdot H_2CO_3$$

or

$$(3)\quad 2\ RNH_2 + H_2S \overset{100\ F}{\underset{240\ F}{\longleftrightarrow}} (RNH_3)_2\ S$$

$$(4)\quad 2\ RNH_2 + CO_2 + H_2O \overset{120\ F}{\underset{300\ F}{\longleftrightarrow}} (RNH_3)_2\ CO_3$$

It should be noted that the reverse reaction is initiated between hydrogen sulfide and the amine at a much lower temperature than is the case for carbon dioxide. Therefore, contact temperatures for hydrogen sulfide removal should be 100 F or lower. Also, as can be expected from the reaction, the disassociation temperature for carbon dioxide is higher than that for hydrogen sulfide. Therefore, although it is possible to obtain virtually complete stripping of hydrogen sulfide from amine solution (H_2S content lower than 10 grains per gallon) at 240 F. approximately 0.5 to 1.0 cu ft of carbon dioxide will remain in each gallon of solution so reactified.

Due to the fact that the reaction is chemical in nature, rather than physical, increasing the strength of the solutions will increase their capacity to remove acid gas. Such increases, however, must be evaluated with care because stronger solutions will not regenerate as completely and the consumption of amine will be higher. For plants using 15-20 per cent solutions of monoethanolamine the amine consumption will vary from approximately 1.5 lb per 1,000,000 std cu ft of gas processed to approximately 0.6 lb, depending on the contact pressure.

In the operation of the aqueous amine gas purification type unit, the operating cycle and the equipment required are very similar to the absorption and stripping process of a natural gasoline plant.

The gas to be purified flows upward through a bubble tower contactor. An aqueous amine solution at atmospheric temperature (80-100 F) enters the top of the tower and flows downward from tray to tray extracting the acid gas. Purified gas leaves the tower at the top. The foul amine saturated with acid gas leaves the bottom of the tower and passes through heat exchangers in which the solution temperature is raised to approximately 180-200 F and into the top tray of the stripper or reactifying still, which is also a bubble tower. This stripper contains in its base, or in an external kettle, a tubular heating element or reboiler. At the top of the stripper are condensers and a water separator. The amine solution flowing downward through the stripper to the kettle is heated to approximately 230-240 F by the hot vapors rising up from the boiling solution in the kettle. The acid gas liberated from the amine solution and a portion of the internally generated stripping steam are carried overhead from the top of the tower through condensers where the steam is condensed and cooled. The condensed steam and cold acid gases are separated in the water separator, the condensate being returned to the top of the stripper as cold reflux and the acid gases are burned in a flare or sent to a processing unit. Hot lean solution stripped of its acid gas content flows from the kettle to the heat exchangers, where heat is exchanged in heating up

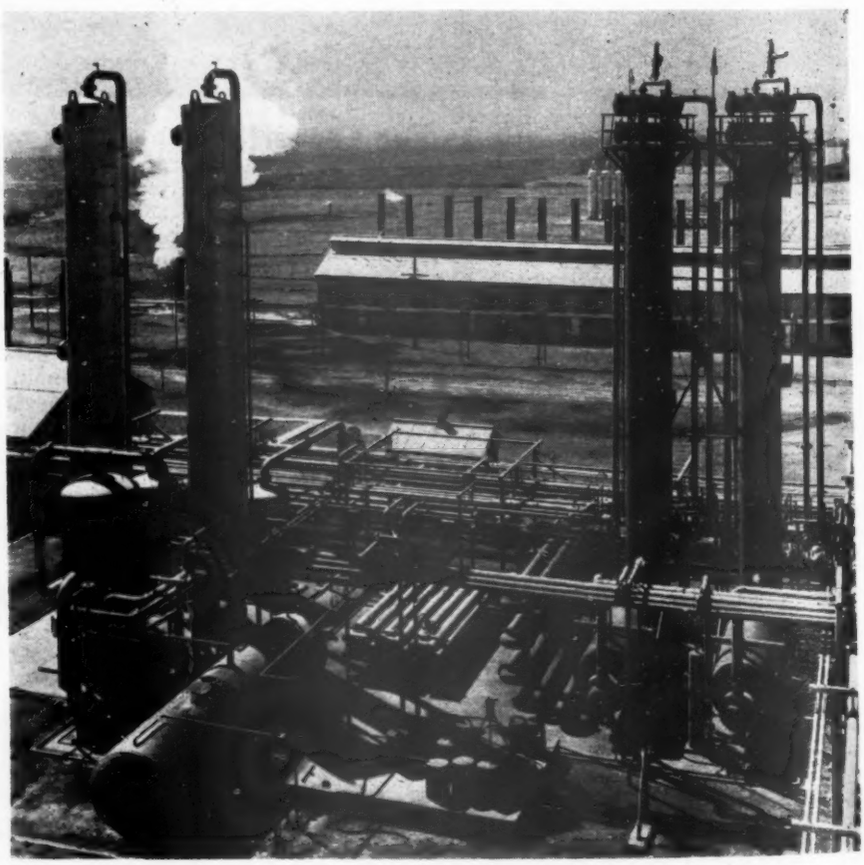

FIG. 7. A picture of a 100,000,000-std cu ft a day amine treater.

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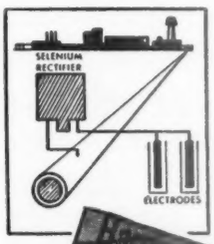

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TABLE 2—Cost of desulfurizing natural gas for pipe line sale.

	Pipe Line Desulfurizer—Capacity 100 MMscfd @ 500 psig		
	1% Acid Gas	3.5% Acid Gas	6% Acid Gas
Investment, $	$980,000	$1,706,000	$ 2,577,000
Operating cost, $—			
Operating and repair labor	24,400	24,400	24,400
Maintenance, material and supplies	13,770	13,870	13,970
Purchased water, electricity and fuel	59,300	128,475	199,500
Chemicals	5,500	5,500	5,500
Total direct operating cost, $/year	102,970	172,245	243,370
Total direct operating cost, ¢/Mcf	0.282	0.472	0.667
Indirect overhead, advalorem taxes and insurance	34,365	65,350	97,500
Depreciation and interest	245,000	426,500	644,300
Total operating cost, $/year	382,335	664,095	985,170
Total operating cost, ¢/Mcf	1.048	1.820	2.700

the cold foul solution, and then through water coolers where it is cooled to approximately atmospheric temperatures. From the coolers the cold lean solution goes to a surge tank from which it is pumped to the contactors thereby completing the cycle.

Because of the fairly rapid rate of reaction in the stripper, virtually complete stripping of the hydrogen sulfide from the solution can be accomplished in a single tower using a steam rate of 1.2 lb of 40 psig exhaust steam per gallon of solution.

As aqueous amine solutions have very little affinity for the hydrocarbon constituents of the gas to be purified, the process is applicable to the desulfurization of field gases prior to gasoline extraction as well as to residue gas.

Although aqueous amine solutions are generally considered to be only mildly corrosive to carbon steel, the susceptibility of the amines to decomposition at elevated temperatures and their tendency to form glycine when in the presence of oxygen make it mandatory that extreme care be used in both the plant design and its operation. Amine solutions also have a tendency to foam especially when in the presence of field gases. Equipment and flow designed to give protection from corrosion and foaming is always expensive. Moreover, as the rate of solution circulation is always directly proportional to the quantity of acid gas to be removed, there can be little correlation based on gas volumes, and each design must be "tailor made." Fig. 7 is a picture of an amine treater having a capacity of 100,000,000 std cu ft a day.

For purposes of economic comparison we are presenting three cases in which 100,000,000 std cu ft a day of gas at 500 psig is to be desulfurized for pipe line sale. The total acid gas content of the gas has been assumed at 1.0, 3.5, and 6.0 mol per cent. As an uninterrupted supply is highly important for a pipe line sale, sufficient standby equipment has been provided in the cost estimates for these treaters so that any shutdowns for maintenance and repairs will not interrupt the processing of gas at full capacity. These precautions have added approximately 25 per cent to the cost of the unit. In addition, the cost estimates are for complete units including steam generating facilities, plant site, camp and buildings, which are not usually included in battery limits plant estimates. The results of this comparison are shown in Table 2. It may be readily seen that the cost of desulfurization will vary proportionately with the acid gas content of the gas.

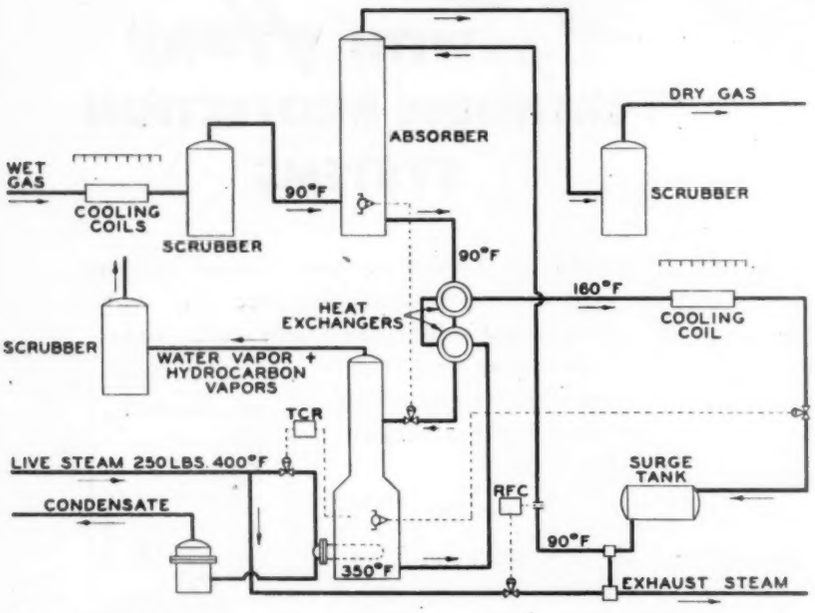


FIG. 8. Flow diagram—glycol dehydrator.

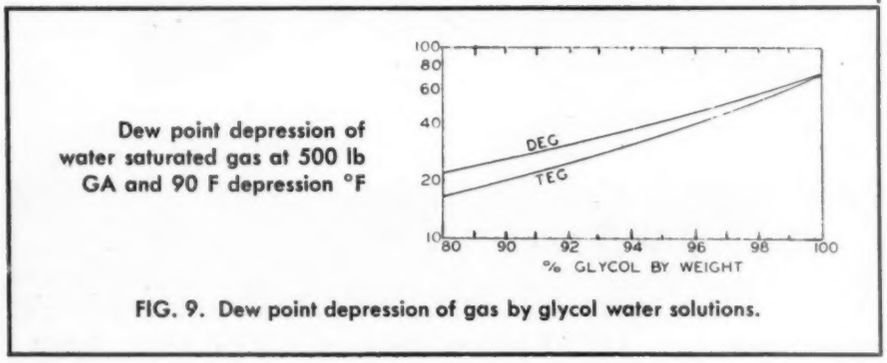


FIG. 9. Dew point depression of gas by glycol water solutions.

Gas Dehydration

Since the early 1930's the need to dehydrate gas to prevent formation of gas hydrates has become more acute with the increasing operating pressures of gas transmission lines and the increasing interest in pressure maintenance of producing fields to promote more efficient oil recovery.

The fact that gaseous substances may form hydrates under conditions that are proper for the combination of gas with water has been known since 1810. Today, thanks to the efforts of E. G. Hammerschmidt, W. M. Deaton, D. L. Katz, D. B. Carson, and many others, we are able to predict the temperature at which gases of varying compositions will form hydrates for any given pressure. Similarly the water content of natural gas at varying temperatures and pressures is known.

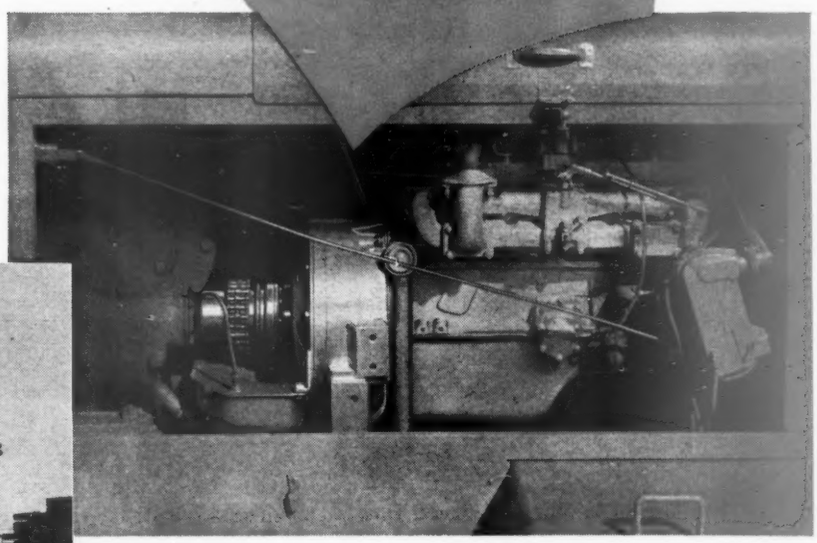
In the early days of hydrate problems, the rate of hydrate formation was controlled by the addition of alcohol, ammonia, ketones, or calcium chloride to the gas. This method is still fairly satisfactory in cases where the conditions favorable to the formation of gas hydrates do not occur frequently; however, inasmuch as we can predict the temperature and pressure at which gas hydrates will form, the best remedy is to reduce the water content of the gas to the point where, at the coldest temperature expected, no free water will be available for hydrate formation. This method of hydrate control has an added advantage in that the transmission lines will be free of internal corrosion and there will be no accumulation of corrosion products to cause increased pressure drop and loss of line capacity.

The two predominant dehydration processes in use today are the absorption type and the adsorption type. In the absorption process the absorbing medium

Announcing UNIT with FLUID TORQUE DRIVE

To a long line of improvements in design and construction, UNIT has added another advancement — FLUID TORQUE DRIVE. This torque converter application gives the operator a steady flow of power which he can regulate with smoothness and accuracy. Elimination of shock loads adds life to bearings, shafts, gears, and cables . . . brings maintenance costs down to a minimum. Excavating work is done with a strong steady flow of power, with no "stall" and no "delay" while the engine regains speed. Crane work can be done with greater smoothness of operation by throttle control.

UNIT offers the Chrysler Torque Converter as a standard installation at no extra cost on ½ yard machines equipped with 6 cylinder Chrysler Industrial Gasoline Engines.



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Time-saving, Cost-reducing Advantages

- Greater work output without increasing fuel consumption
- Eliminates "shock loads" on machinery, reducing maintenance cost
- Smoother and more accurate control of all operations
- Builds up line pull without excessive load on engine
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- Quick engine pickup retains maximum line speeds
- Provides "regulated load handling" by throttle control
- Increases lugging power for hard excavating
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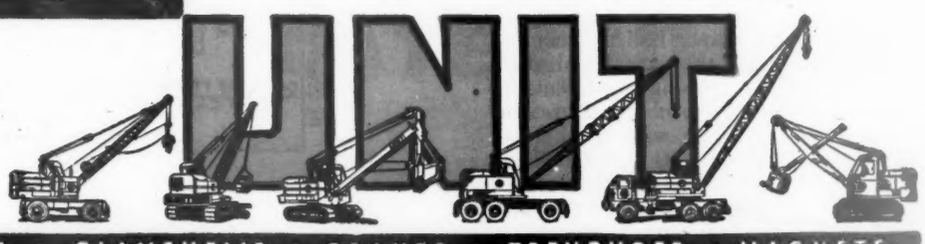
Other UNIT machines are available in ½ and ¾ yard Excavators and Cranes up to 20 Tons . . . Crawler or Mobile Types . . . Gas or Diesel . . . Fully convertible to ALL attachments. Write for descriptive literature.



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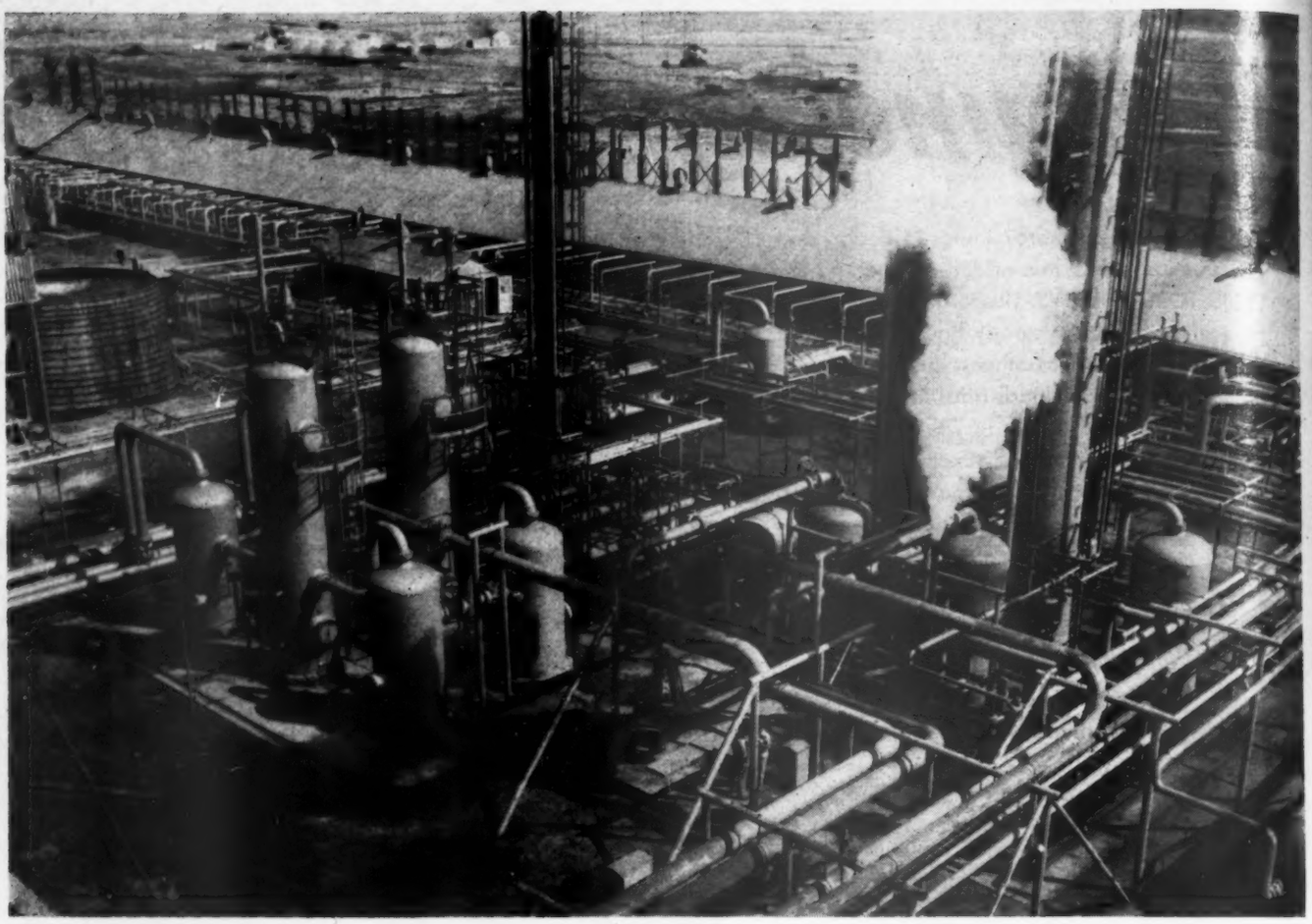


FIG. 10. A diethylene glycol unit.

is usually diethylene or triethylene glycol. In the adsorption process the adsorbing medium is a dry desiccant, which may be bauxite, silica gel, activated alumina, or a special siliceous material such as Sovabead.

The glycol absorption process involves the same stripping and absorption cycle as is employed in the aqueous amine process described previously. A flow sketch is shown in Fig. 8. As this process is truly one of absorption, however, the quantity of glycol circulated will be directly proportional to the quantity of gas for any given pressure.

Assuming adequate glycol circulation, the dew point depression obtained will depend on the particular glycol selected and the purity of the still kettle product. Fig. 9 shows the theoretical dew point depressions that may be obtained by using each of the two common glycols in varying degrees of purity. This chart was calculated on the basis of Raoult's law without regard for deviations. Actually it is possible to obtain dew point depressions approximately 10 per cent greater than shown.

Although the graphs indicate that diethylene glycol is the superior absorping medium on a weight percentage basis, it is possible to obtain a greater dew point depression with triethylene glycol because, due to its higher boiling point and higher temperature of decomposition, a higher degree of purity can be procured as a still kettle product. For a 500-psig absorption system operating at 90 F a dew point of approximately 40 F can be obtained in commercial operation with diethylene glycol whereas with triethylene glycol a dew point of 30 F can be obtained. As contact temperatures are lowered so are the dew points but in a lesser degree.

As contact pressures are increased the maximum dew point depression obtainable decreases so that at approximately 1200 psig the dew point depression will be approximately 75 per cent of that for 500 psig.

Therefore glycol dehydrators are limited in their ability to prevent hydrate

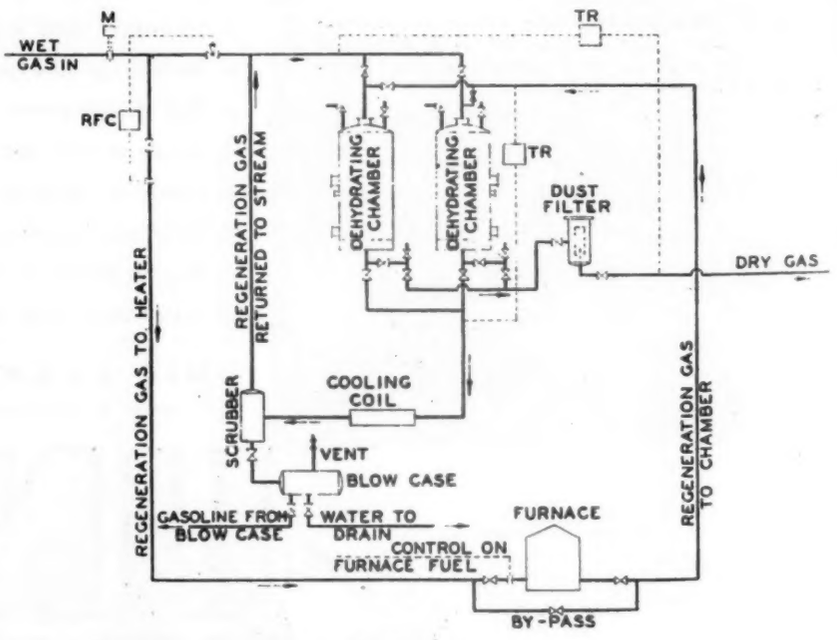
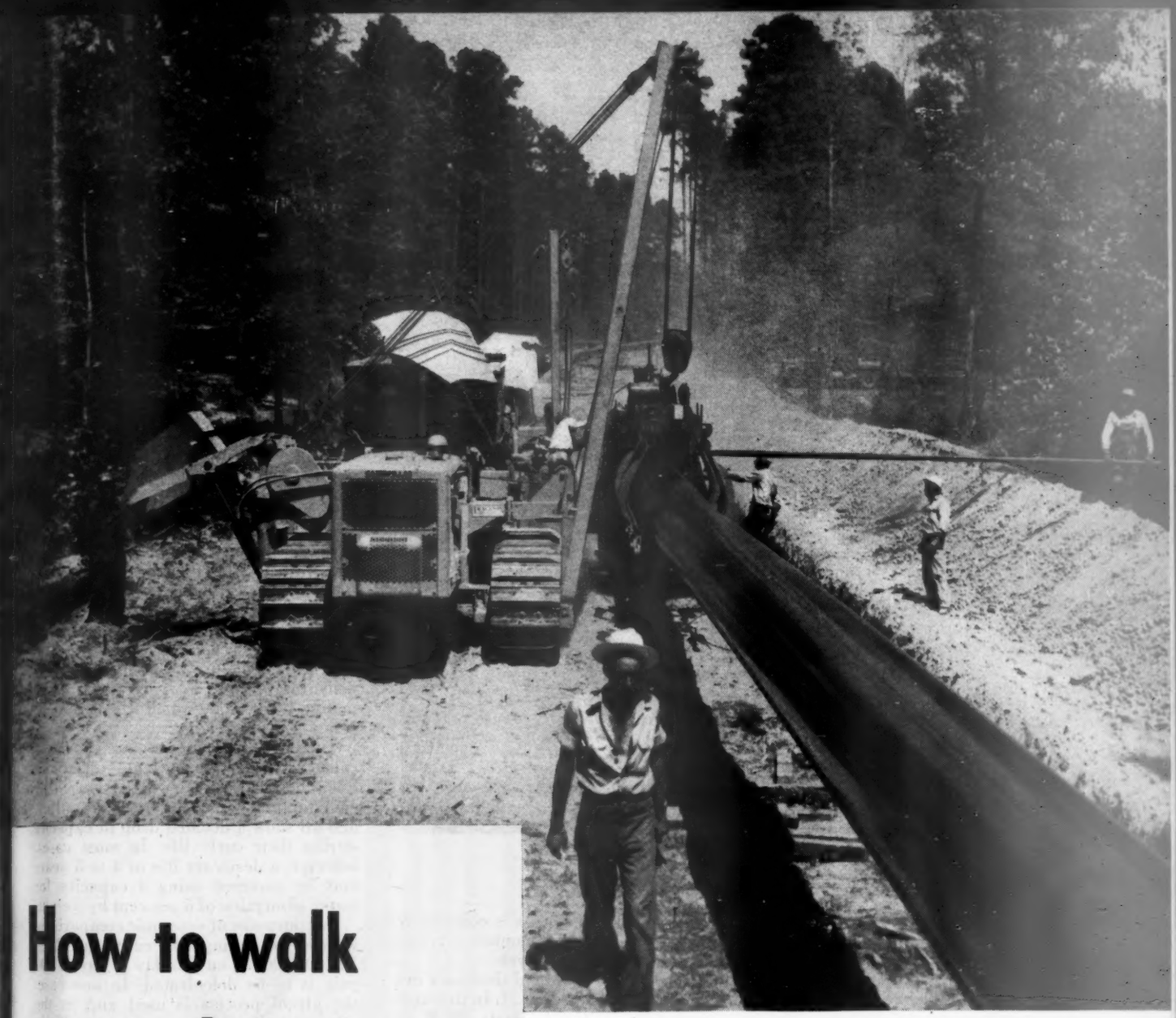


FIG. 11. Flow diagram solid type dehydrator.



On a section of the Beekman-Eunice, La., spread, near the Ouachita River, a "Caterpillar" Diesel D8 Tractor with Trackson Pipe Layer cradles 26-inch pipe for the dope machine.

How to walk a pipe line in

Between Beekman and Eunice, Louisiana, Houston Contracting Company is laying a 26-inch line to carry gas for the Texas Gas Transmission Company. This isn't the kind of giant operation that's featured on the front pages of metropolitan newspapers, but it could well serve as a pattern for good pipe-line practice.

A team of "Caterpillar" Diesel D8 Tractors, equipped with Trackson Pipe Layers, is moving the job ahead at a steady 9,000 feet per 10-hour day. With offset tracks, properly balanced weight and plenty of lifting power, these big yellow machines don't halt for stiff grades or river crossings. They just keep rolling along.

One reason why "Caterpillar" track-type Tractors and Trackson Pipe Layers are the No. 1 tool of the pipe-line crews is their rugged construction. They're built to take a beating day after day, and their dependable engines prevent costly down-time on cross-country work. Another reason is the prompt, on-the-job service provided by "Caterpillar" Dealers everywhere.

You can get the full story of how this equipment speeds pipe-line work—all the way from pioneering to backfilling—from your own nearby "Caterpillar" Dealer. And he'll back it up with facts.

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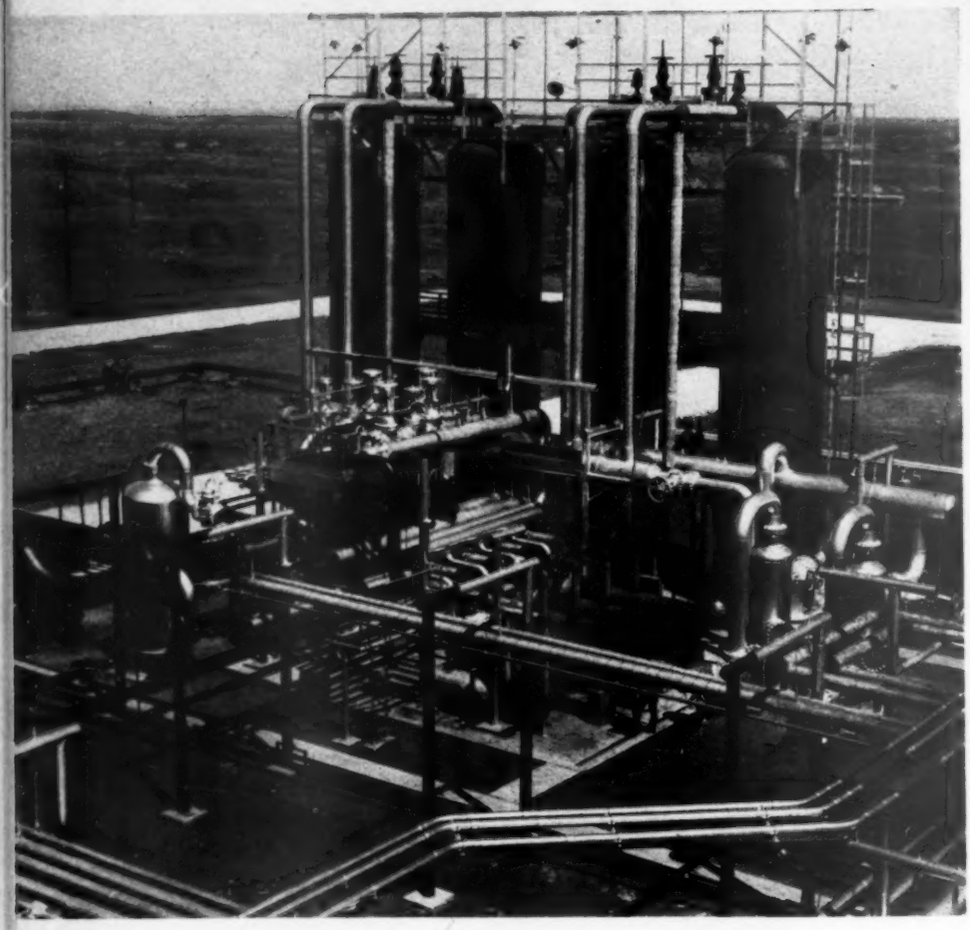

FIG. 12. A solid desiccant dehydrator.

formation when the gas to be dehydrated is at high pressures and subjected to the winter temperatures prevailing in cold climates.

Glycol dehydrators have a great advantage over the adsorption process dehydrators in the cost of installation. Fig. 10 is a picture of a diethylene glycol unit having a capacity of approximately 100,000,000 std cu ft a day at 500 psig.

The adsorption process dehydrators employ the solid type of desiccants and are capable of reducing the dew point of a gas to a point well below 0 F. The process may be called a continuous-batch, as two or more chambers are employed, one being used for drying gas and the other, a spent chamber, being regenerated. Operations are regulated so that when the desiccant in one chamber is approaching the limit of its capacity to adsorb water, the other is completely regenerated and the chamber services are switched on a time cycle.

A flow sketch of a solid desiccant dehydrator is shown in Fig. 11. In this unit gas cooled to approximately 90 F is passed downward through a bed, or beds, of desiccant where the moisture content is removed by adsorption. The dry gas emerging from the bottom of the chamber is then sent through dust filters before being delivered to the pipe line or other uses.

A portion of the gas to be dehydrated (10-20 per cent of the total) is diverted from the main stream of gas and sent to a heater where the temperature is raised to approximately 375 F. The hot gas emerging from the heater is passed downward through a chamber containing desiccant that has previously been saturated with water adsorbed from wet gas. As the bed is heated up by direct contact with the hot gas, the equilibrium is reversed and the bed gives up its water content. This heating process is continued until the temperature of the outlet gas reaches 325-350 F. At this time the regeneration gas stream is allowed to bypass the heater and the hot desiccant is cooled by direct contact with additional gas. This cooling is continued until the outlet gas is within approximately 20 F of the inlet gas. At this time the chamber is considered to be completely regenerated and ready for use.

The hot regeneration gas saturated with water is cooled in water coolers to a temperature of 90 F and the excess water removed in the water scrubber. Gas leaving the water scrubber is returned to the gas stream being dehydrated.

In this process the gas is thoroughly dehydrated. The chief disadvantages of the process are the high cost of installation and the pressure drop required, which can amount to a considerable requirement in compressor horsepower. Fig. 12 is a picture of a solid desiccant dehydrator having a capacity of approximately 100,000,000 std cu ft a day at 500 psig.

The life of the materials used as desiccants is subject to extreme variations. Some desiccants are easily poisoned by contamination with oil, others by sulfur, and all show a decided drop in capacity during their early life. In most cases, however, a desiccant life of 4 to 5 years may be assumed using a capacity for water adsorption of 5 per cent by weight.

For purposes of economic comparison, we are presenting two cases in which 100,000,000 std cu ft a day of gas at 500 psig is to be dehydrated. In one case, the glycol process is used and in the other the dry desiccant process. These results are summarized in Table 3.

Because dehydration plants can ordinarily be shut down for short periods for maintenance purposes and the gas by-passed to prevent interruptions in gas delivery, very little standby equipment was included in the investment cost. As in the case of the desulfurizer, however, the cost of steam generating facilities, camp, plant site, and buildings is included. In addition, the cost of the gas cooling equipment is included.

This cost comparison is not truly indicative of the two methods, as the solid desiccant unit can process 125,000,000 std cu ft a day if a higher pressure drop can be tolerated, whereas the maximum capacity of the glycol unit is 100,000,000 std cu ft a day.

It is hoped that this paper will contribute something to the conservation of our natural resources by showing how the desulfurization and dehydration of natural gas are being accomplished.

TABLE 3—Cost of dehydrating natural gas for pipe line sale.

	Pipe Line Dehydrator—100 MMscfd Capacity	
	Glycol	Dry Desiccant
Investment, $	$445,000	$710,000
Operating costs, $—		
Operating and repair labor	21,800	21,800
Maintenance material and supplies	10,110	10,110
Purchased water, electricity and fuel	4,500	11,570
Chemicals	8,750	2,100
Total direct operating cost, $/year	45,160	45,550
Total direct operating cost, ¢/Mcf	0.124	0.125
Indirect overhead, advalorem taxes, and insurance	14,600	14,600
Depreciation and interest	180,750	180,000
Total operating cost, $/year	168,510	240,180
Total operating cost, ¢/Mcf	0.462	0.658

Acknowledgment

The authors wish to express their appreciation of the work of other Phillips Petroleum Company personnel who have contributed material used in the preparation of this paper. * * *

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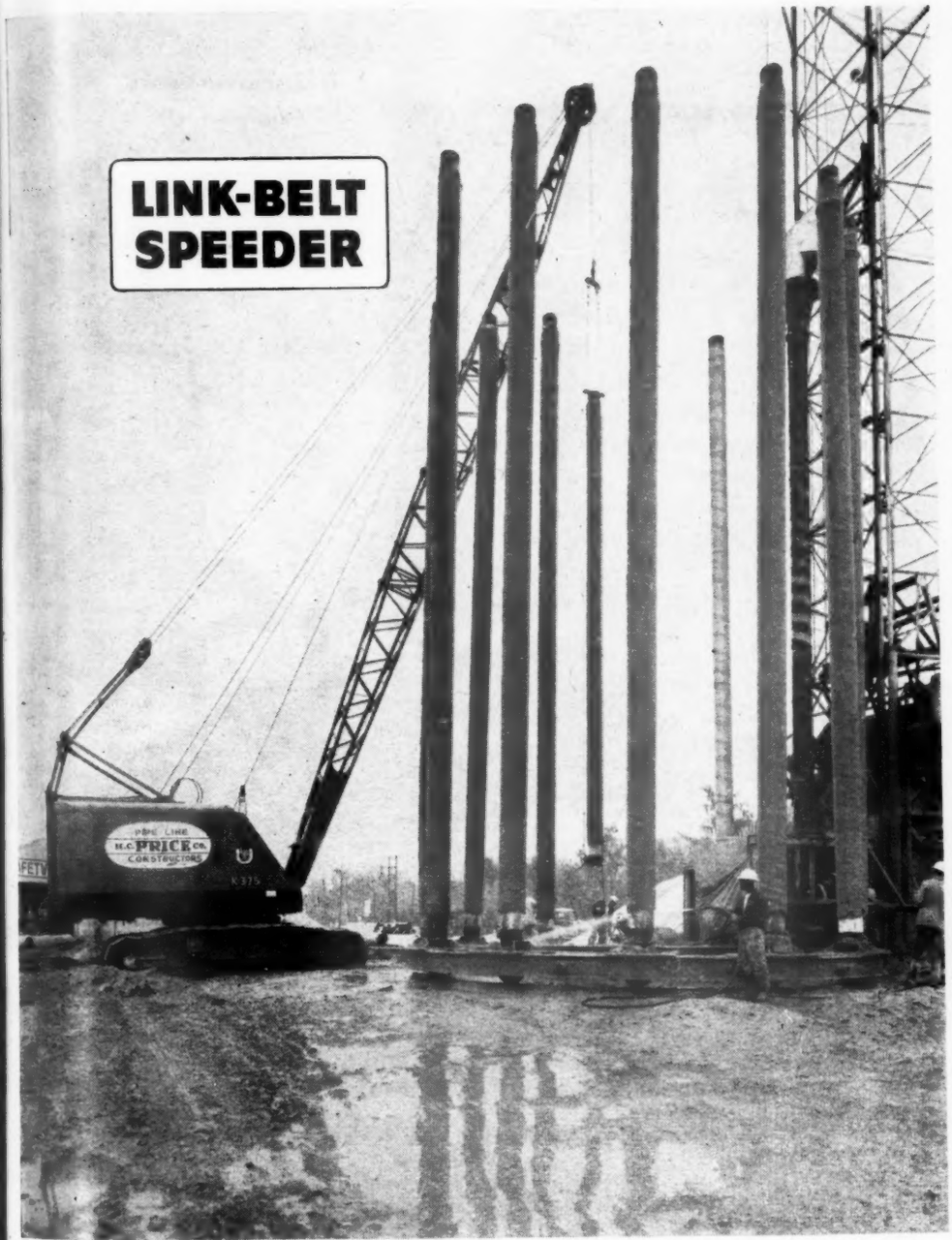
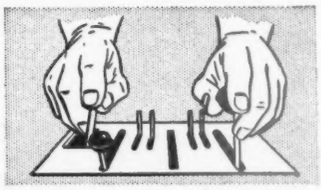
H. C. Price Co. uses a K-375 with power hydraulic controls

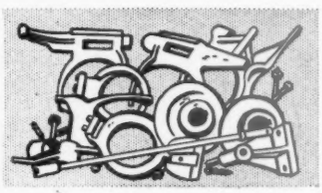


H. C. PRICE CO., Bartlesville, Okla., owns three Link-Belt Speeders. At their Harvey (La.) plant above a K-375 unloads raw pipe . . . dips wrapped pipe into cement vats . . . loads wrapped and cemented pipe into barges. According to Superintendent S. D. Pugh, they're "very well pleased with production."

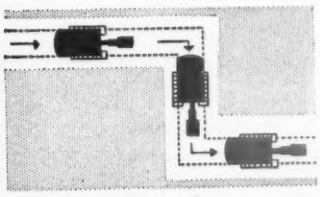
Here are LINK-BELT SPEEDER PLUS FEATURES that work for you



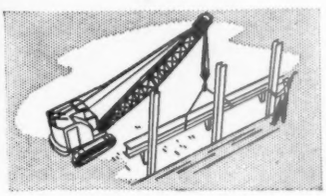
Speed-o-Matic Controls — fully hydraulic! You "feel" the load all the way. Simple, easy—fingers instead of muscles do work.



Eliminates up to 150 parts — cuts friction, no worn bushings, pins, links or clutch toggles to put you "down."



Turns on a Dime. Either track can drive or be locked independently. Hydraulic control gives instant response.



Pinpoint Accuracy — eliminates lost motion. Instant response assures spotting heaviest loads—easily, precisely. 12,890

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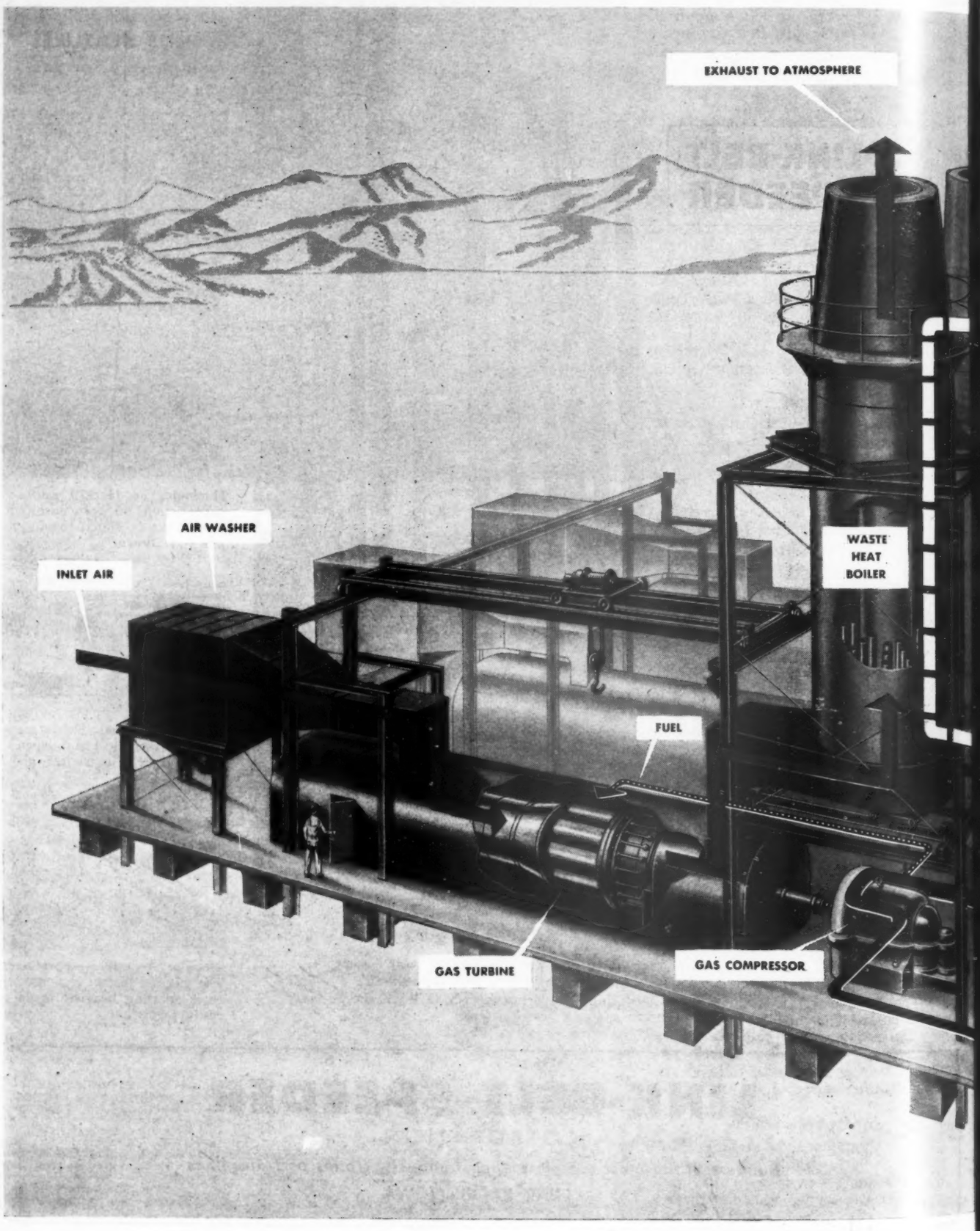
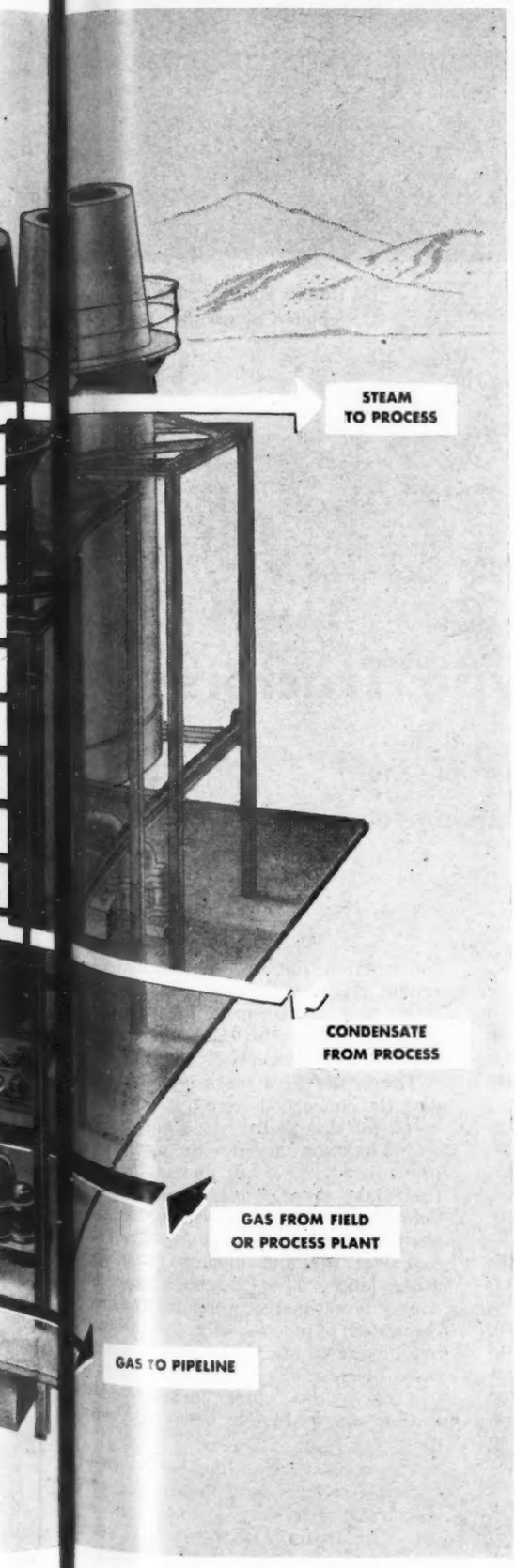
G-E combustion gas turbine f



ne for oil and gas fields



Outdoor unit eliminates building cost, generates low-cost steam, can be easily re-located

Latest suggested applications for General Electric's versatile 5000-hp combustion gas turbine is in field gathering and to increase the flow of gathered gas to processing plants.

There are three immediate advantages. *First*, no building is needed. Both the adjustable-speed gas turbine and the centrifugal compressor are designed for outdoor installation. *Second*, this compact G-E power plant can be moved easily from depleted fields to new fields. (A single rigid bedplate permits handling of the turbine with only a crane.) *Third*, each turbine can also generate as much as 30,000 lbs of 225-psig saturated steam at very little cost.

Cuts total yearly costs

Because less personnel is required than with other types of drives, yearly operating costs of a gas turbine driven centrifugal-compressor are very low. Maintenance costs are exceptionally low, too. The comparatively few moving parts of a gas turbine are all rotating. As a result, maintenance is mostly a matter of periodic inspection. Standard-type auxiliaries and accessories are conveniently located to simplify replacement. In addition, the gas turbine can provide up to 25% more horsepower in winter, when demand is greatest.

Available now

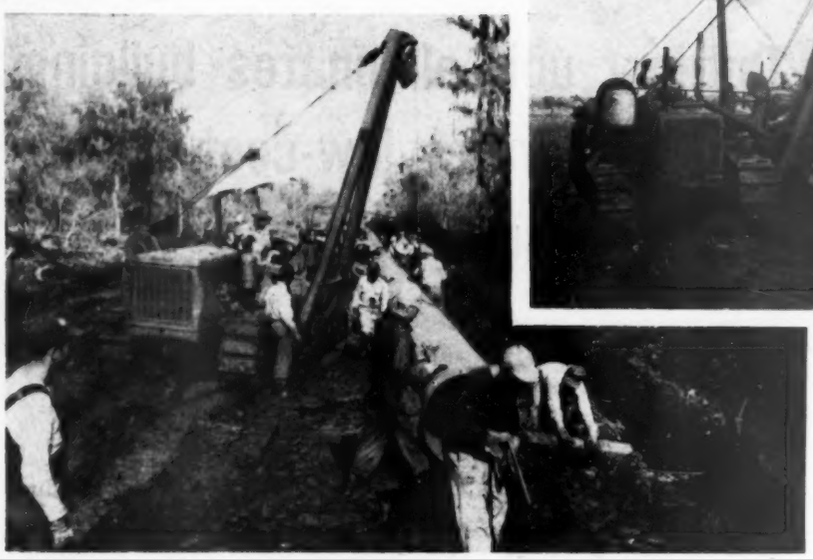
In a large Western gas and electric utility, one G-E combustion gas turbine has already logged-in more than 20,000 hours of operation. Another has been driving a locomotive for over two years. A number of others are being installed for gas pipeline pumping. Now their unique advantages are ready to be supplied to field gathering, natural gasoline and cycling plants, and repressuring projects. Your G-E representative will be glad to discuss your applications with you.

FOR YOUR INFORMATION, a 16-page illustrated booklet gives you the full story about G-E's combustion gas turbine. Call your nearest G-E Sales Office for your free copy of Bulletin GEA-5530, or write *Section 661-31, General Electric Company, Schenectady 5, N. Y.*

Combustion Gas Turbines for the Petroleum Industry

GENERAL ELECTRIC

D4 tractor unloads pipe from truck pulled by another D4 tractor.



D7 tractor lining up a joint of pipe for welding.

Maintenance of Track-Type Tractors

Here is a program that will make possible the realization of full potential life of equipment

V. A. WOODLING*

ALMOST 50 years of research, design, and improvements have produced the modern track-type tractors and have brought them into their own throughout the world. Wherever heavy loads are to be moved they have become a necessity. Their advancement is a story of continued engineering, research, development, and manufacturing technique. There is also a story of increased productivity and economy brought about through conscientious maintenance.

The manufacturer, wherever possible, has enclosed tractor parts or used ingenious seals to protect them from their arch enemy—dirt. He has made use of new metals and heat-treating processes to produce tougher and more wear-resistant members. He has promoted, in cooperation with the oil industry, the use of new lubricants to ever-increase the performance life of his product. He has rearranged the operating controls and provided other means to reduce operator fatigue. He supplies complete instructions covering the necessary servicing. The manufacturer, by numerous developments, has extended greatly the operating periods between overhauls. He has helped reduce operating costs by producing a better, more easily maintained product.

Many selling dealers have established at considerable expense, extensive service facilities staffed with highly skilled service personnel and equipped with the most modern tools and fixtures. In addition, he has available for immediate delivery almost any required repair part. His establishment can render quick efficient service in the shop or on the job site in the field in event of breakdown. The dealer has promoted educational programs for the owner's operating personnel and through these has reduced and, in many instances, prevented expensive delays. Thus, the dealers' activities have greatly influenced the reduction of operating costs.

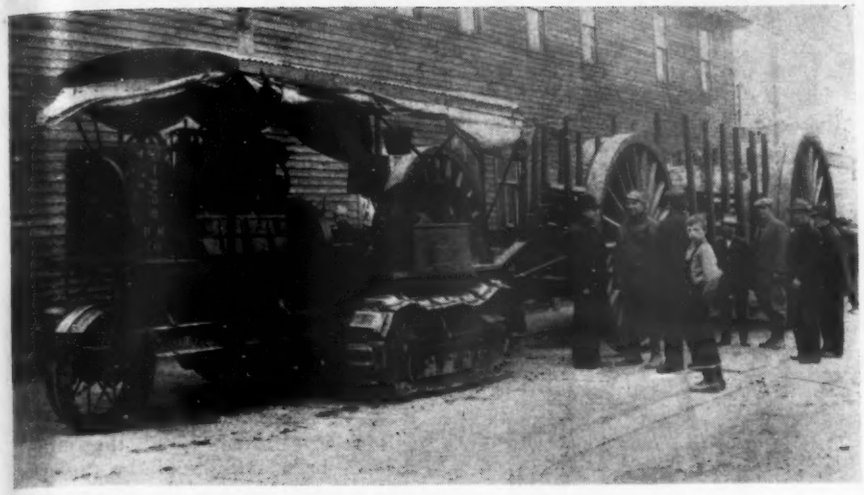
Despite the many improvements in construction, the advanced facilities for repair, and the developments in materials and lubricants, these modern machines still require periodic carefully planned maintenance.

The owner of a track-type tractor is directly concerned about its operating costs, for this figure has a major effect on his balance sheet for the operation—profit or loss. All but one of the items that make up the costs are fairly well defined: Purchase price, depreciation, parts replacement or repair due to normal wear, fuel and lubricants, and operating labor. The variable figure that cannot be estimated, nor sometimes even computed, is the cost of premature wear or damage to one or several associated parts because of neglect. In addition to the cost of the repairs, must be added the loss in production because of down time.

The improvements that have been designed and built into the tractor were incorporated by the manufacturer because he believed that eventual usage would place the tractor under conditions

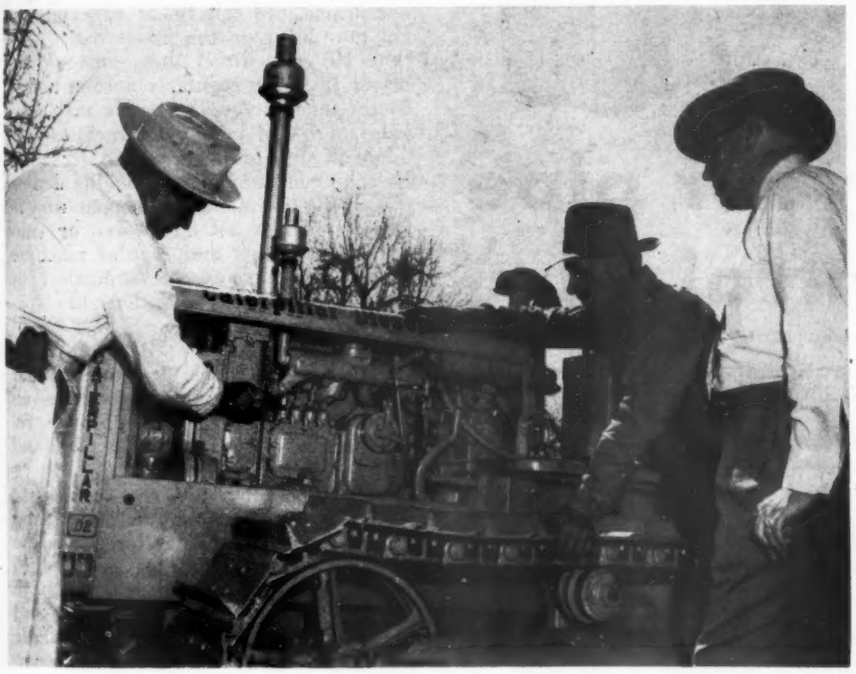
*Manager, Service Development Division, Service Department, Caterpillar Tractor Company.

EXCLUSIVE



One of the early Caterpillar tractors, built about 1908,

and a late model — the Caterpillar Diesel D2.



far from the ideal, that the operator may be inexperienced and that maintenance people may handle their work—adjustments and lubrication—on an "if and when" basis. Someday, such improvements may produce a permanently lubricated and adjusted machine. Today, even with the 50-years' advancement, some degree of consideration on the part of the operator and maintenance man must be received if the full potential life built into the tractor is to be realized.

Maintenance, as we know it, consists of four separate considerations:

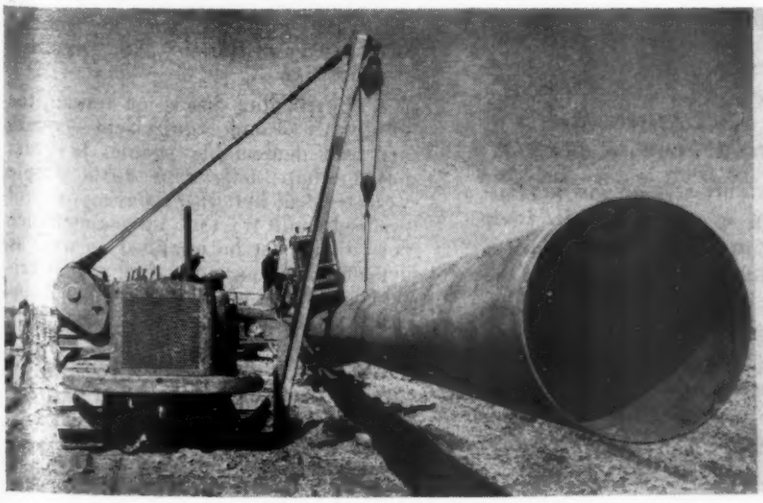
1. Adjustments to compensate for normal wear.
2. Adequate lubrication of the working parts.
3. A general tightening of shock-loosened bolts, nuts and capscrews, and minor parts replacement.
4. Prevention of the entrance of dirt, abrasives or other foreign materials into the working parts.

Continuous attention must be directed to the supply and use of recommended lubricants. There are air cleaners and breathers to be inspected and cleaned. There are oil levels and pressure gages to check, compartments to drain, and numerous incidental or miscellaneous jobs to accomplish such as cleaning the trash from in front of a radiator or removing frozen mud from track carrier rollers.

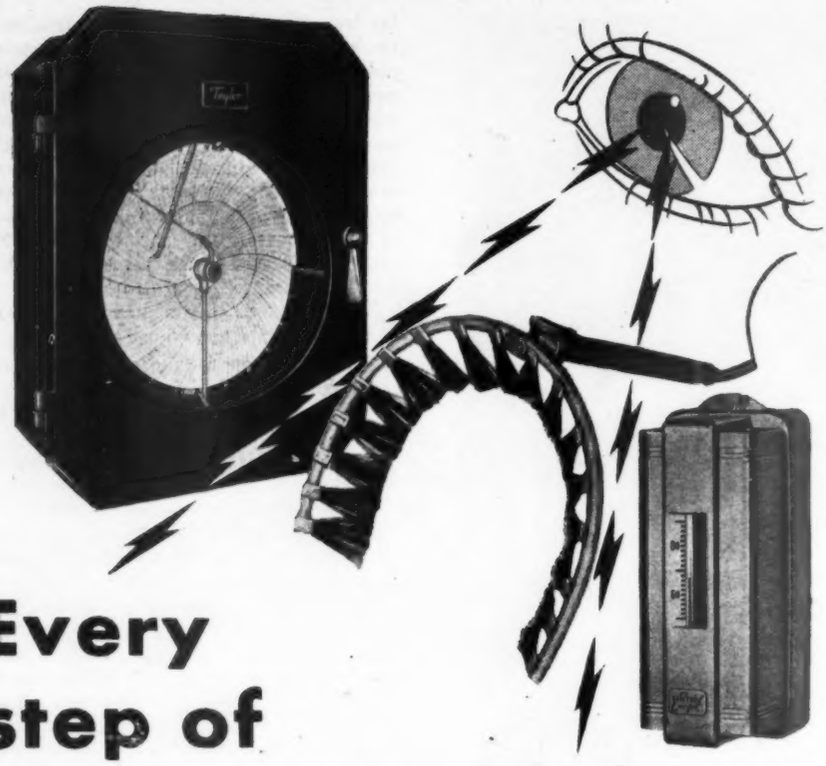
The manufacturer, through experience and from suggestions from owners, has found that 10-hr intervals are the most convenient for accomplishing the maintenance operations on the equipment. For that reason, operator's instruction books recommend inspection and lubrication periods of 10, 20, 60, 120, or 240 hr to allow easy maintenance scheduling. Gear compartments, for example, should be drained and refilled at 900-hr periods, or about every two months on a 20-hr day 5-day per week working schedule.

Looking through the details of the maintenance recommendations, we begin to realize the size of the requirement. Multiply this by the number of units on

A Diesel D7 tractor equipped with sideboom holds pipe for cleaning and priming machine on pipe line construction job in Texas.



Diesel D8 tractor equipped with No. 8A bulldozer smooths surface for ditcher on pipe line construction job.



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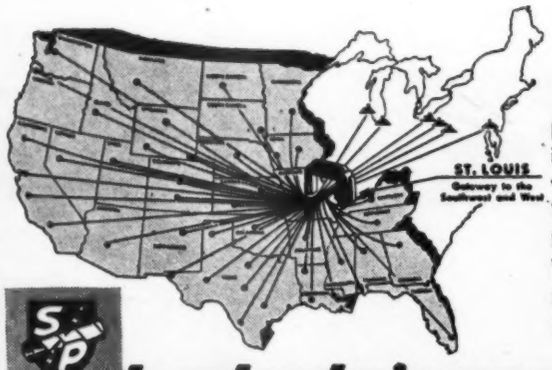

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the job and the responsibility becomes enormous. Who, when, and with what will we do the fueling, lubrication, adjustments, repair, or minor replacements? The individual requirements must be faithfully and properly accomplished, for it is the grease fitting that was consistently missed, or the adjustment that never was made, that can quickly relegate an otherwise serviceable machine to the "dead line."

The apparent enormity of the job demands some method of organization or simplification, otherwise there is no assurance that 98 per cent, 70 per cent, or even 25 per cent of the points that need greasing, adjusting, or cleaning will receive attention at the proper time. A brief analysis of the problems should reveal some of the answers.

Any plan or program requires someone to direct it, that is, to be the "bossman." One person to delegate and fix responsibility among others is the first step toward organization. On the larger operations, the equipment superintendent may head up the maintenance section. He may direct that some of the minor tasks be regularly accomplished by the machine operators. He may provide a crew of people for the periodic on or off shift oil changes and greasing. He may contract with a machine dealer to provide a trained serviceman who is responsible for all day-to-day or running adjustments and regular machine inspection. In short, the supervisor of these maintenance operations has specifically assigned each and every detail that makes up the overall requirement. Experience has shown fleet owners that specific written instructions for each job are a necessity and they produce results instead of repair bills, excuses, and alibis.

The owner of a few tractors should apply the same reasoning in establishing his program. The only difference is the number of responsibilities assigned to an individual. His operators may have to accomplish all the lubrication and running adjustments while his mechanic may handle all the oil changes, in addition to making minor parts replacements and periodic inspections.

Regardless of the number of tractors on the job, someone must be available to schedule, supervise, and inspect the entire maintenance operation. Let's give this part of the program the general title, "Administration and Organization."

The preceding discussion reveals the program's second requirement — qualified and dependable people. In years past perhaps only dependable people were needed, but with today's powerful precisely-built tractors, the maintenance personnel must be qualified as well as dependable. Operators, fuel and lubricant handlers, mechanics, and maintenance superintendents must know the "how," "when" and "why" of maintenance. Unfortunately, the number of these individuals is not increasing. One may find plenty of "floaters" but not always the conscientious "regular."

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couraged to learn more about their work. They should know from cover to cover the contents of the instruction book that is provided by the manufacturer. In addition, they should be given access to meetings held for mechanics, to repair literature and charts supplied by the manufacturer. They should be present whenever a dealer is delivering a new machine.

The more an individual knows about the exact construction and function of each part or assembly the greater the chance that he will avoid future trouble. For example, track roller seals can be destroyed by the uninformed using air-operated greasing equipment, which develops many times more pressure than the seals will withstand. The haphazard tractor maintenance performed by the "strong back" employee has cost some owners a lot of money. Qualified, dependable, continuously trained people make up the second part of the program.

The third requirement of an organized maintenance program is facilities — a place to work and tools with which to work. Supplied with each new machine is a package of tools consisting generally of hand grease guns, oil cans, volume oil dispensers, and certain special wrenches for conveniently adjusting clutches or other parts. In addition, there is an assortment of tools for general tightening. The manufacturer supplies the basic essentials of the facility requirement, and with these a good job of maintenance can be accomplished. This has been often demonstrated by the individual owner. If tractors are operating singly or away from any base maintenance organization, it is important that the maintenance equipment be kept complete and in good operating condition and accessible to the tractor, preferably on the machine. Each grease gun or pump should contain an adequate supply of the *proper* lubricant. It will be found virtually impossible to encourage an operator to do the lubricating, make minor running adjustments or general tightening if his tool equipment is not available or in good operating condition.

The larger fleet owner generally has concentrated his maintenance facilities either in a field shop or mobilized and convenient to any machine scheduled for servicing. The same requirements exist for these expanded facilities—tools and equipment must be accessible, easy to use, complete, and in good working order. Improper equipment is almost certain to result in improper maintenance.

We now have fixed the responsibility for maintenance on a qualified administrator who has written and given specific instructions and latitudes of duties and responsibilities to a group of capable people, and he has provided them with the time and the materials with which to accomplish their assignments. There remains one other problem — that is the elimination of guesswork about what is to be done, who is to do it, and when. Some workable system of records seems to be the answer.

The two fundamental advantages of records are obvious:

1. They fix responsibility.
2. They eliminate failures of the human memory.

Let us examine each.

A conscientious, dependable employee can do his job more thoroughly if he is expected to submit a written record of his work, because then there is no escaping the repercussion if he has failed in his responsibility. If there are several people who share a particular job, as would occur when the machines are working and serviced on two or three shifts, there can be no conflict between the shifts as to which one was supposed to do the work.

The maintenance superintendent, after observing the manufacturer's recommendations, directs that a certain shaft be lubricated after each 60 hours' operation, and he expects the shaft to be lubricated each 60 hr, not 80 nor 100 hr. Unless he has readily available for the maintenance crew a record listing

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Continuous Weld—Plain End	2⅜" to 4½" O.D.	Up to 40'	Standard	Fontana, Calif.
Electric Resistance and Fusion Weld—Plain End	8⅝" to 20" O.D.	Up to 40'	.188" to .500"	Napa, Calif.—Basalt-Kaiser
Electric Resistance Weld—Plain End	5 9/16" to 12¾" O.D.	Up to 55'	.188" to .375"	Fontana, Calif.
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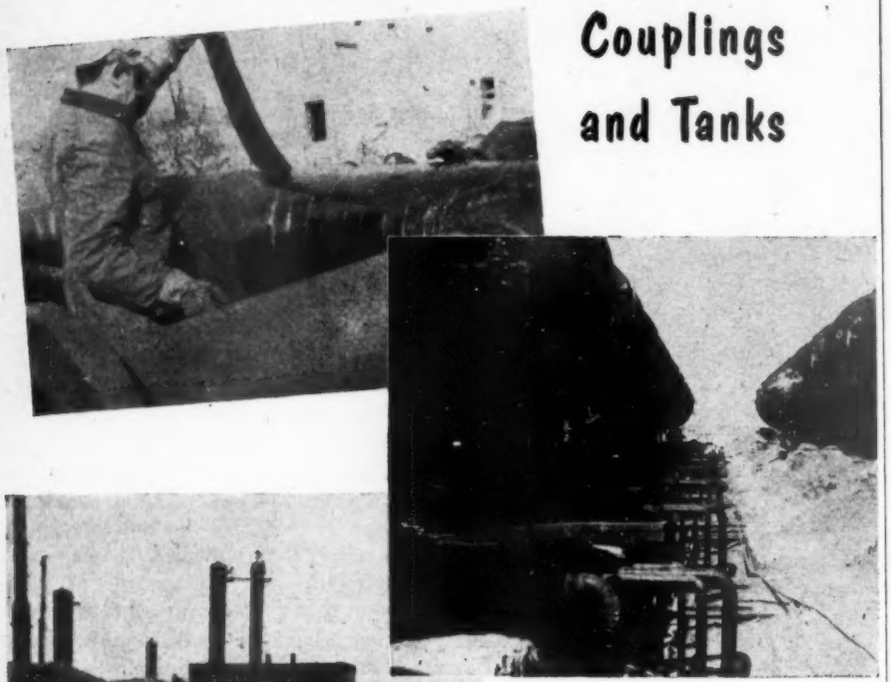

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the exact time for the next lubrication, the shaft will receive attention only by guesswork. Depending upon the memory of individuals is certain to lead to additional expense for repair or down time.

These records need not be elaborate. In fact, the more simple they are the greater are the chances that they will be consciously kept up-to-date and not filled in just prior to a routine check. The essentials are: Spaces for the hour-meter readings, a listing of the operations to be performed, and the hour-intervals for performing them. If the maintenance operations are divided, as lubrication and adjustments, make up a separate record for each man or group to keep. Much help on the development of the necessary forms can be gained from information contained in the instruction book for maintaining the machine. These books have a complete lubrication guide and contain a section outlining the recommended adjustments and other maintenance operations. From this and other information, the various tasks can be divided and delegated to the operator, the mechanic, or the lubrication man.

The "apparent enormity" of the maintenance requirements can indeed be reduced to a very workable routine. It is fundamentally a matter of (1) who has the primary responsibility, (2) why and how does the job have to be done, (3) what tools must be provided to accomplish quickly and accurately the work, and (4) what assurance is there that the job was completed at the proper time?

Ask yourself these four questions, and develop the answers with your own organization. Your own answers will write a story of increased productivity and economy brought about through fewer breakdowns, lowered repair and operating costs. * * *

Northern Natural Buys Permian Basin Pipe Line

Northern Natural Gas Company announces the purchase of 51 per cent of the Permian Basin Pipe Line Company.

The Omaha company also holds an option to purchase the entire capacity of the Permian Basin, which plans to build a pipe line system for transporting natural gas from the Permian Basin area to Skellytown, Texas, where it will connect with Northern's system.

The Permian company now has on file with the Federal Power Commission an application to build these facilities at an estimated cost of $60,000,000. The proposed project will have a daily capacity of 200,000,000 cu ft the first year and 300,000,000 cu ft after that.

Permian's business office will be transferred from Chicago to Omaha.

Four of Northern's officers have been elected to Permian's board of directors. They are President John Merriam and Vice Presidents W. L. Shomaker, A. B. Dilworth, and J. M. Hanley. Other members of the board are W. D. Gay of Kansas City, Missouri, president of Permian, John Fennelly and P. A. Walters, both of Chicago.

Pipe Line Fluid Network Calculator

Determining analytically flow distribution and head loss in large fluid systems with special equipment

L. M. HAUPT

THE difficulty of calculating analytically the flow distribution and head loss in large fluid systems, either actual or contemplated, is such that it is practical to use special equipment and techniques to obtain this information.

The fundamental relationships used to solve any flow distribution problem analytically are: (1) that the algebraic sum of the flow to a junction is zero, and (2) that the algebraic sum of the head losses around any closed loop is zero. A third relationship—the relation between flow and head loss for any section of the conducting medium — has been determined experimentally and expressed by the empirical equation:

$$h_L = KQ^{1.85} \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Where:

h_L is the head loss

Q is the flow

K is a constant depending on the length, diameter, and condition of the pipe, kind of fluid, and the units in which the head loss and flow are expressed. This equation is derived directly from the Hazen-Williams formula in common usage.

This formula is further simplified into:

$$R = \frac{h_L}{Q} = KQ^{0.85} \quad . \quad . \quad (2)$$

where R is defined as the resistance to flow.

Electrical analogies have been and are being used successfully to determine the flow distribution and head loss in fluid systems. By letting head loss be represented by voltage and fluid flow by current, the first two fundamentals above are satisfied by the electrical network.

The third relation may then be met by repeated adjustment of linear resistances. This method, when used by trained operators in any of the established *a-c* or *d-c* network calculator (analyzer) laboratories, is rapid. Furthermore, the results obtained may be made as accurate as desired, limited only by the precision of the instruments and resistors. To obtain results accurate within 4 or 5 per cent usually required not more than three adjustments.

The third relation may also be met by the use of non-linear resistors having the same flow characteristics as the fluid under study. It has been found that tungsten filaments enclosed in evacuated tubes have approximately the same resistance-flow characteristic as equation (2). Calculators have been built employing this type of special resistive element. The increase in resistance with current is due to the increase in temperature of the filament.

A satisfactory circuit element to substitute for the above is a variable ratio auto-transformer that has a tungsten filament incandescent lamp across the secondary. This arrangement has two distinct advantages: (1) These lamps are easily obtained and are of low cost, and (2) the turn ratio of the auto-transformer may be varied to reflect any given value of resistance (within limits) to the circuit.

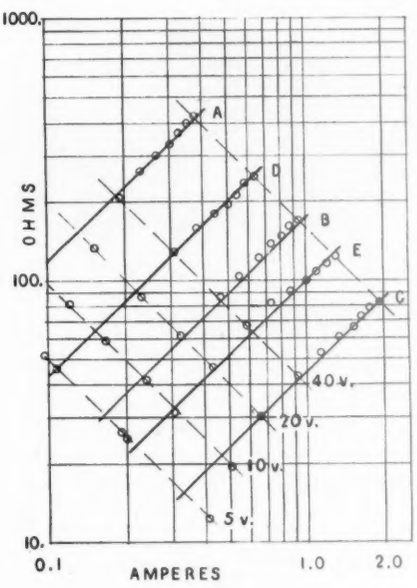
The resistance-flow characteristics of tungsten filament lamps, both direct and reflected through a transformer, are shown in Fig. 1. The plotted points are from actual laboratory data. The curves (straight lines) are drawn with a slope of 0.85 through a point derived from the nominal voltage and wattage rating of the lamps. The correlation between the plotted points and the curves show that the relation expressed by equation (2) is followed closely, particularly if the lamps are coupled to the circuit through a transformer. The relation is followed almost exactly through the range wherein the filament may be seen to glow; that is, from 40 v up on a nominal 120-v lamp.

Lamps are designed for a useful life of 1000 hr. Over-voltage, which causes the lamp to absorb more than rated power, greatly shortens its life. On the curves, Fig 2, is shown the current in the auto-transformer primary that causes

The Author

Lewis M. Haupt, Jr., is professor of electrical engineering, Agricultural and Mechanical College of Texas; research engineer, Texas Engineering Experiment Station (a part of the Texas A & M system); and supervisor of the A-C Network Calculator Laboratory, Texas A & M Research Foundation. He received his bachelor of science degree in electrical engineering, Texas A & M College, 1927, and his master of science degree, Texas A & M College, 1935. After graduation he was employed by the Westinghouse Electric Corporation, East Pittsburgh, Pennsylvania, as a student engineer and returned to Texas in 1928. He was with the West Texas Utilities Company, Abilene, Texas, two years before returning to Texas A & M College as a member of the teaching staff in 1930.

Haupt is a member of the American Institute of Electrical Engineers, the American Society of Engineering Education, Texas Society of Professional Engineers. He is a member of Tau Beta Pi.



LEGEND

A— 40w, 120v lamp
B—100w, 120v lamp
C—200w, 120v lamp
D—200w lamp adjusted to 200 ohms 0.5 amperes
E—200w lamp adjusted to 100 ohms 1.0 ampere

FIG. 1

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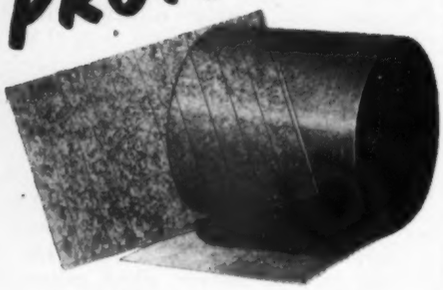

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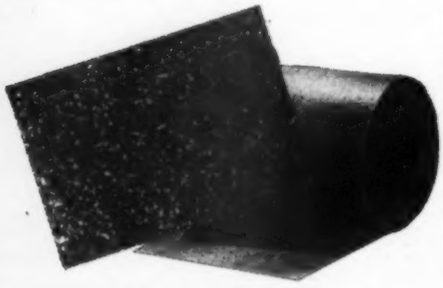

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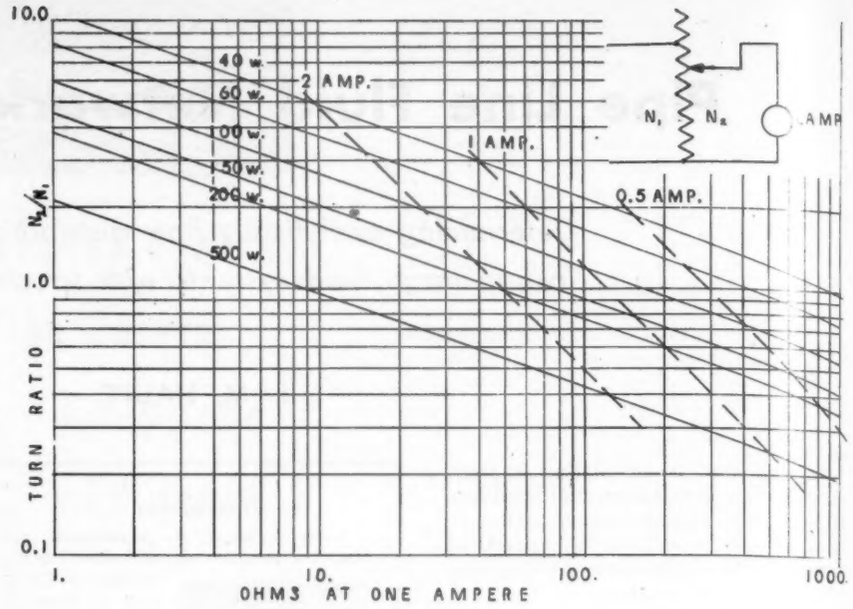

FIG. 2

TABLE 1.

(a) Circuit	(b) R_0 ohms at 1 amp	(c) Lamp size, watts	(d) Transfer ratio N_2/N_1	(e) I flow	(f) V Head loss
G	....	....	....	....	100[1,2]
A	30	240*	1.00	1.20	45.3
B	50	200	0.95	0.74	28.8
C	100	150	0.90	0.46	22.6
D	1000	150	0.35	0.06	6.0
E	....	....	....	0.40[1]	25.9[2]
F	....	....	....	0.80[1]	32.1[2]

* 200 watt and 40 watt in parallel.
[1] Given data.
[2] Head.

rated power to be taken by the lamp for the various turn rations. These curves may be used both in selecting the size of lamp to use as well as in selecting the turn ratio to use for any particular lamp and resistance.

In practice it is necessary to assume electrical equivalents. For example, 1-ft head loss may be assumed equivalent to 1 volt and a flow of 10,000,000 gal per day equivalent to 1 amp. From the physical dimensions of the pipe line network, the equivalent electrical resistance at 1 amp is calculated. In the following example, the given data is in electrical equivalents. After the electrical resistances were set (using Fig. 2), the voltage at G and the flows of E and F were adjusted to conform to the given data. The flow and the voltage of each circuit was read with instruments.

A tabulation of the results is shown in Table 1. It is found that the results check closely the values calculated by more commonly used methods and well within the accuracy usually required for this type of problem.

Example

Given: The fluid system, Fig. 3, is supplied from a single source having a head of 100 v (electrical equivalent) and connected to two loads, E and F, in which the flows are 0.40 amp and 0.80 amp (electrical equivalents) respectively. The electrical equivalent resistance at one ampere of each section is shown on the diagram. Determine the flow and head loss of each section and the head of each load.

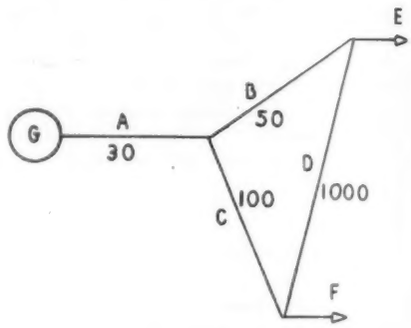

FIG. 3

Solution: The electrical circuit is "set up" using as circuit elements lamps and transformers settings determined from Fig. 2. The lamps and settings selected are tabulated in Columns c and d of Table 1. The voltage input is adjusted to 100 v (given) and the loads are adjusted to 0.40 amp and 0.80 amp respectively (given). The head loss and flow of each circuit is read by electrical instruments and tabulated in Columns e and f, respectively.

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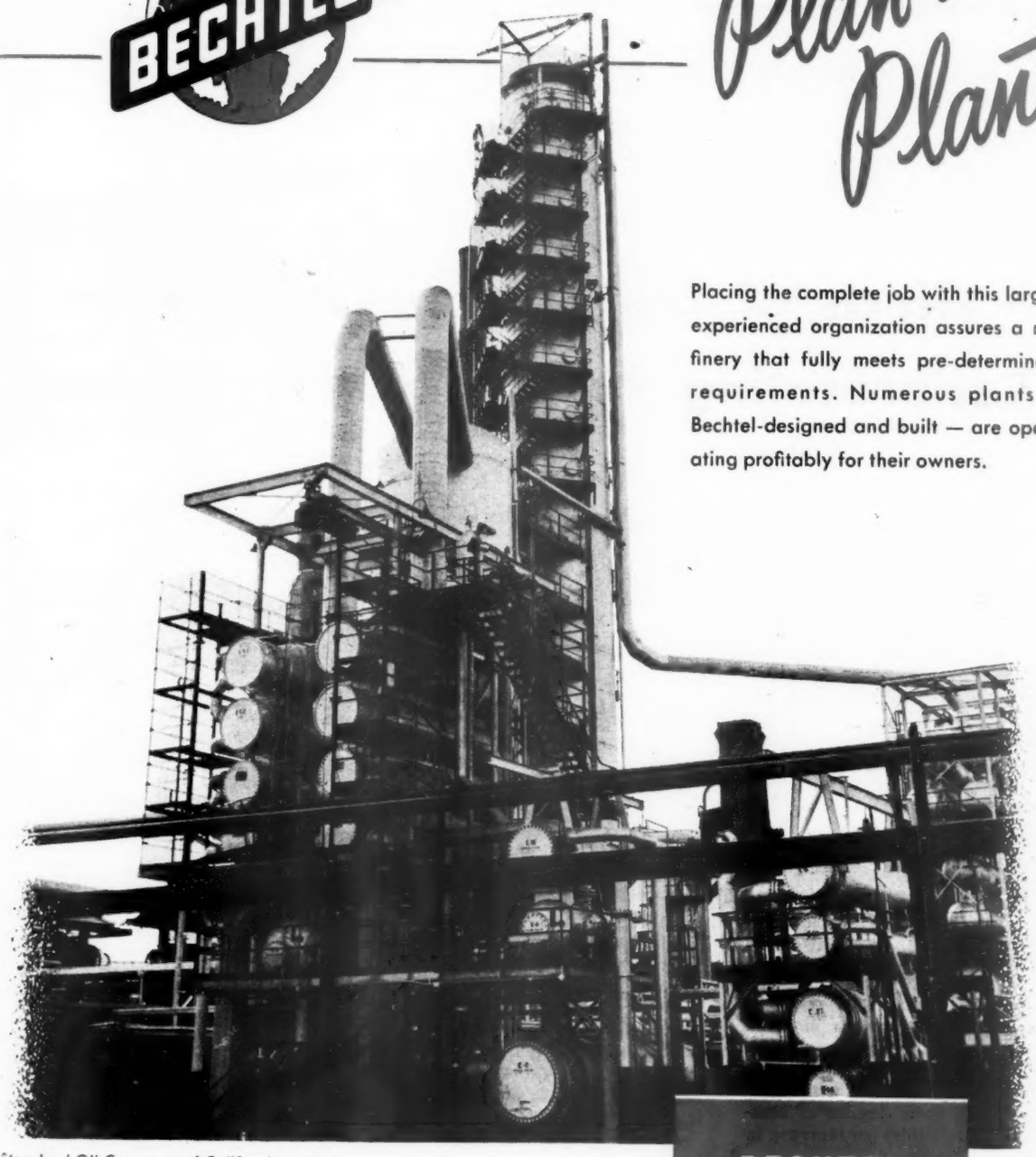

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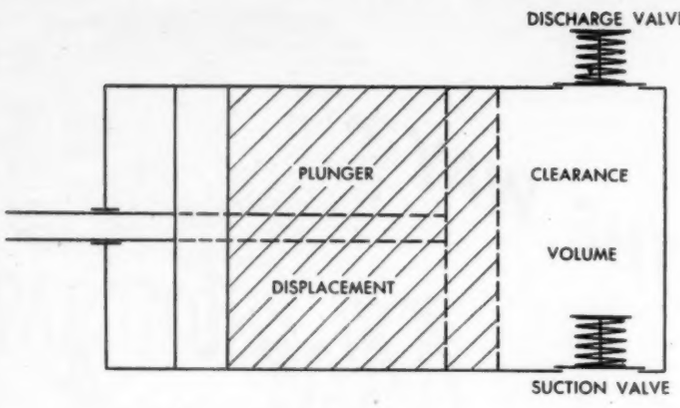

FIG. 1.

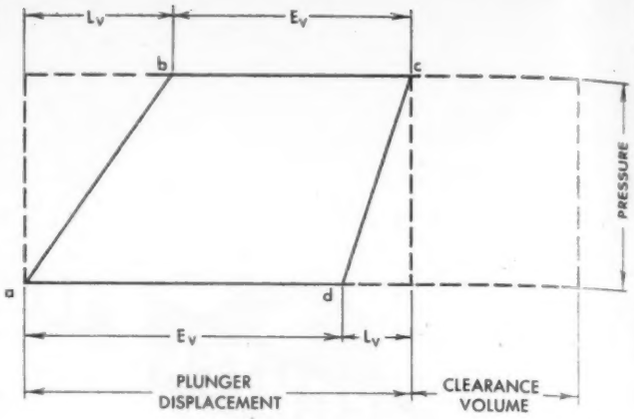

FIG. 2.

Effects of Fluid Compressibility on Reciprocating Pump Volumetric Losses

R. K. GROBHOLZ*

OFTEN heard is the term, "incompressible liquid." The mistaken notion that most fluids are not compressible is a fallacy that has given many an engineer a headache. This can be especially true in the application of high-pressure reciprocating pumps.

Actually all liquids are compressible, the degree of compressibility depending upon the liquid itself, its temperature, and the increase in pressure. For example: 100 gal of water (often termed "incompressible") at atmospheric pressure and temperature, shrinks to 97.1 gal under a pressure of 10,000 psi.[1] If the same 100 gal were at an initial temperature of 200 F, the compression would reduce the volume to 96.8 gal. Generally speaking, for the same increase in pressure, highly volatile liquids such as ammonia and the liquefied petroleum gases, will compress more than water or heavier oils. Listed in the table that follows are some common liquids with their degree of compressibility for each 1000 psi increase in pressure.

In connection with Table 1, the following should be noted. Experiments indicate compressibility factors change according to the pressure levels at which they are measured. For example, a liquid will compress more from 1000-2000 psi than from 8000-9000 psi. Very little factual data are available to permit expansion of the subject in this article.

Table 1. Compressiblity factors.
(Per 1000 psi differential)

Liquid	Temp F	Factor	Liquid	Temp	Factor
Water.....	68	.0029	N-butane	68	.0193
	200	.0032		86	.0228
				104	.0274
Lube oil....	68	.0044		122	.0323
	122	.0050			
			Iso-butane	68	.0239
Kerosene...	68	.0051		86	.0285
	104	.0057		104	.0341
				122	.0415
Gasoline....	68	.0075			
	122	.0090	Propane	68	.039
				86	.050
Ammonia...	0	.0060		104	.066
	68	.0098		122	.096
	100	.0133			

For the purpose of calculating volumetric losses in reciprocating pumps, the compressibility factors in Table 1 can be assumed as constant for whatever pressure conditions may exist. Results from the use of these factors will, if anything, be on the conservative side.

Effect on Reciprocating Pumps

A schematic diagram for a single-acting piston pump is in Fig. 1.

On the suction stroke, the piston moves to the left. This creates a partial vacuum behind the piston. The pressure in the suction pipe should be greater than inside the pump, which forces open the suction valve and permits the pump to fill. After the suction stroke has been completed and the cylinder filled with liquid, spring loading closes the suction valve. The piston moves back to the right on the discharge stroke, compressing the fluid in the cylinder. As soon as the pressure inside the cylinder exceeds the pressure on top of the discharge valve, that valve will open and the liquid displaced by the piston will be forced out.

Theoretically then, the amount of liquid pumped should equal the volume displaced by the piston. For piston pumps, however, leakage may occur past the piston packing. For both piston and plunger pumps, leakage can also occur at liquid valves and stuffing-boxes. The resulting differential between displacement and actual capacity is called "slip"; and the ratio of capacity to displacement is termed "volumetric efficiency". In most instances, slip remains fairly constant — about 4 per cent of the piston or plunger displacement. This means the volumetric efficiency could always be considered as 96 per cent, except for one thing—compressibility.

Although the same problems of compressibility apply equally to piston or plunger pumps, the words piston and plunger may be used interchangeably throughout this article. If more emphasis is placed on plunger pumps, it is only because their structural design makes them more suitable than piston pumps for high pressures where compressibility is more noticeable.

[1]Based on compressibility factors for water; 5th edition "Marks' Handbook for Mechanical Engineers."

*Application engineer, Worthington Corporation.

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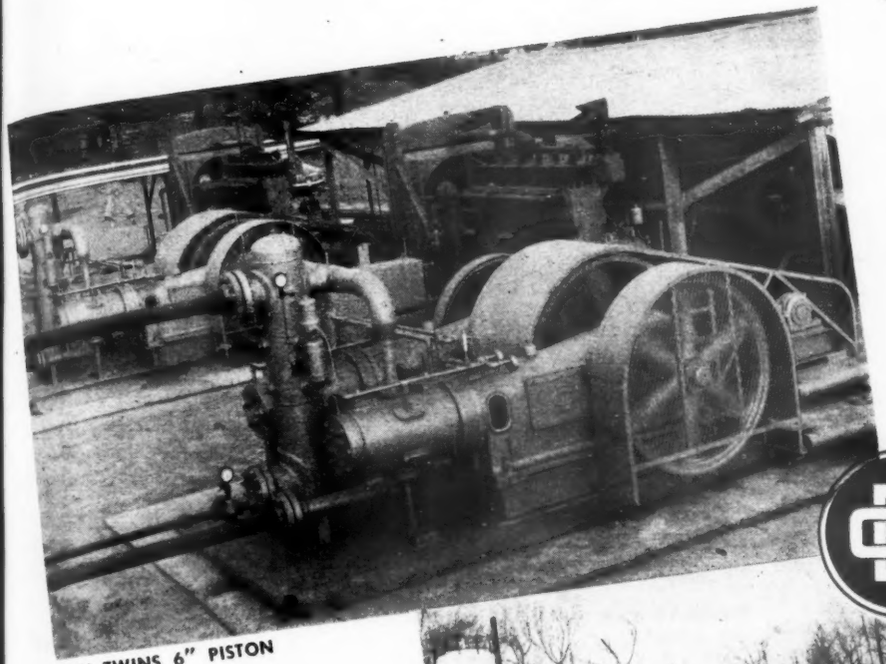

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Clearance

Another factor that must be considered in connection with the calculation of volumetric losses for fluid compression, is that of clearance. Clearance volume is that space remaining within a pump cylinder between suction and discharge valves and the piston, when the piston has completed the discharge stroke. (See Fig. 1.) Clearance is usually expressed as "per cent clearance" denoting the ratio of clearance volume/plunger displacement.

An indicator card for one single-acting plunger of a pump handling a highly compressible fluid would look like that shown in Fig. 2. *a-b-c* is the discharge, *c-d-a* the suction stroke. From *a* to *b* the plunger is compressing the liquid to that pressure required to open the discharge valve. Thus, no flow can be expected until the plunger reaches *b*. The displacement of the plunger then, from *a-b* is wasted in compression. To determine volumetric losses and volumetric efficiencies, the following factors must be considered.

P — Plunger displacement volume
C — % clearance-clearance volume/P
K — Compressibility of the liquid expressed as a decimal for the pressure differential
S — Slip—usually .04
L_v — Volumetric losses

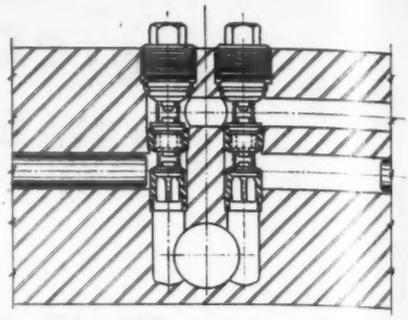

FIG. 3. Typical section of a double-acting, close clearance plunger pump. The placement of valves, small plunger bore and position of the plunger at the end of its stroke, all keep clearance space to a minimum.

E_v — Volumetric efficiency

Clearance becomes of great importance because the volume to be compressed by the plunger on the discharge stroke includes clearance volume as well as the volume displaced by the plunger itself. The greater the compressibility factor of a liquid, the lower the clearance should be in the pump selected; otherwise volumetric losses may be unreasonably high. Pump vendors will be glad to supply clearance data for any of their products on request.

Capacity Measured at Discharge Pressure

The volumetric losses, measured at the discharge side of a pump, become;

$$L_v = S + (1 + C)\ K$$
$$E_v = 1 - L_v = (1 - S) - (1 + C)\ K$$

If $S = .04$
$E_v = .96 - (1 + C)\ K$ for capacity at discharge pressure.

Example

30 gpm propane @ 86 F. 3000 psi disch. press. Flooded suction pump clearance C = .50

Compressibility (from Table 1) = .05/1000 psi

$$*K = \frac{3000}{1000} \times .05 = .15$$

$$E_v = .96 - (1.50 \times .15) = .735$$

To obtain 30 gpm discharge capacity, a pump must be selected for $\frac{30}{.735}$ or 40.8 gpm plunger displacement.

Capacity Measured at Suction Pressure

The rate of flow into the suction of a high-pressure pump may be more important than discharge capacity. This might hold true if a pump were required to empty a suction tank of certain gallonage in a specified time. It is interesting to note that under such conditions, the plunger displacement for which a pump is selected will not be the

*Note that K is for the differential between suction and discharge pressure, not discharge pressure alone.

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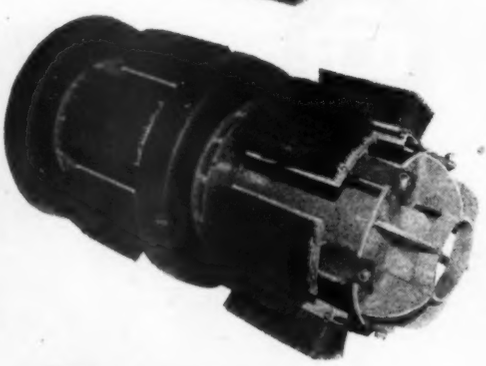

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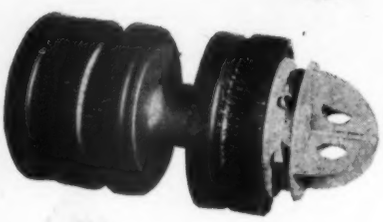

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same as if the identical capacity were required as discharge pressure.

Refer again to Fig. 2. The suction valve will not open until the pressure within the pump has dropped below that in the suction pipe. At the end of the discharge stroke (c), a quantity of liquid at discharge pressure is trapped in the clearance space. As the plunger backs away, this liquid tends to re-expand, until at point (d) its pressure is low enough to permit the suction valve to open. From *c* to *d*, the plunger displacement is wasted in re-expansion of fluid from the clearance space. Expressed mathematically:

$$L_v + C = S + \frac{C}{1-K}$$

$$L_v = S + C\left(\frac{1}{1-K} - 1\right) = S + \frac{CK}{1-K}$$

$$E_v = 1 - L_v = (1-S) - \frac{CK}{1-K}$$

If $S = .04$

$$E_v = .96 - \frac{CK}{1-K}$$

for capacity at suction pressure.

Example

Same conditions as previous example

$$E_v = .96 - \frac{.50 \times .15}{.85} = .872$$

To obtain 30 gpm suction capacity, a pump must be selected for $\frac{30}{.872}$ or 34.4 gpm plunger displacement.

Horsepower

When conditions of service make compressibility negligible, the normal method of figuring horsepower requirements for reciprocating power pumps is to use the actual capacity (displacement minus .04 slip) in the well known formula;

$$BHP = \frac{\text{gpm} \times \text{diff. press.}}{1715 \times \text{pump mech. eff.}}$$

In the case of the aforementioned liquid, which is not substantially compressed, capacities measured at suction and discharge pressures are equal.

If service conditions make compressibility a serious factor, capacities at suction and discharge pressures will, as previously shown, differ, for a pump running at constant speed. The problem becomes on which capacity to base horsepower calculation. Actually, the BHP under compressible conditions is the mean between the displacement horsepower and the suction capacity horsepower;

$$BHP = \text{Displacement HP} \times .96 - \frac{CK}{2\ (1-K)}$$

Example

Propane @ 86 F; 3000 psi discharge press., flooded suction pump displacement 40.8 gpm; pump mech. eff.—84%

Pump clearance $C = .50$ $K = .15$

$$\text{Displacement HP} = \frac{40.8 \times 3000}{1715 \times .84} = 85$$

$$BHP = 85\left(.96 - \frac{.50 \times .15}{2 \times .85}\right) = 78 \text{ BHP}$$

Summary

In summation, when a liquid with a high compressibility factor is pumped against considerable differential pressure, expansion and compression of fluid within the pump necessitates a larger pump and/or greater speed than for the same capacity if compressibility were negligible.

Greater BHP is required too, but not as much as if the pump were handling a liquid of negligible compressibility at a capacity corresponding to the increased plunger displacement.

Acknowledgments

C. W. Boegehold, Worthington Pump and Machinery Corporation. "Compressible Liquids," February 15, 1950.

* * *

☆ ☆ ☆

Since 1926, general living costs have risen 44 per cent, food has increased 61 per cent and house furnishings are up 76 per cent. In the same period, the price of gasoline, without taxes, has dropped from an average of 20.9 cents per gallon to 20.5 cents per gallon, a decrease of two per cent. But taxes on gasoline are 177 per cent higher than they were in 1926.

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Operating side view of one of nine Nordberg 1210-hp supercharged and intercooled Duafuel diesel engines on new Phillips Products Pipe Line. Engine shown is installed at Sharpe, Kansas, station.

Diesels Power New Products Stations

SUPPLYING additional power for pumping 82,000 bbl a day of refined products over the new Phillips products pipe line expansion are nine Nordberg Duafuel diesel engines with a total rating of 10,890 hp. This line, which extends more than 1000 miles from Phillips' Borger, Texas, refinery, to distribution points at Kansas City, Kansas, East St. Louis, Illinois, and East Chicago, Indiana, now represents one of the most modern and efficient carriers in service.

The Nordberg engines were installed by Phillips Pipe Line Company to give flexibility in line operation and maximum capacity from the 8-in to 12-in. hydraulically balanced line. The units operate either separately or in conjunction with older pumping units installed in alternate stations. In addition to Borger, the Nordberg engines are operating in stations at Spearman, Texas; Laverne, Oklahoma; Hardtner, Attica, Wichita, Sharpe, Paola, and Bonita, Kansas. The Paola station is the division point for lines to Kansas City and St. Louis.

The engines are of the four-cycle type, both supercharged and intercooled, and have eight cylinders of 13-in. bore and 16½-in. stroke. They are each rated 1210 hp at 460 rpm. Each engine drives a United Iron Works six-stage centrifugal pump through a Westinghouse speed increaser with a ratio of 1:8.024 (460 to 3600 rpm).

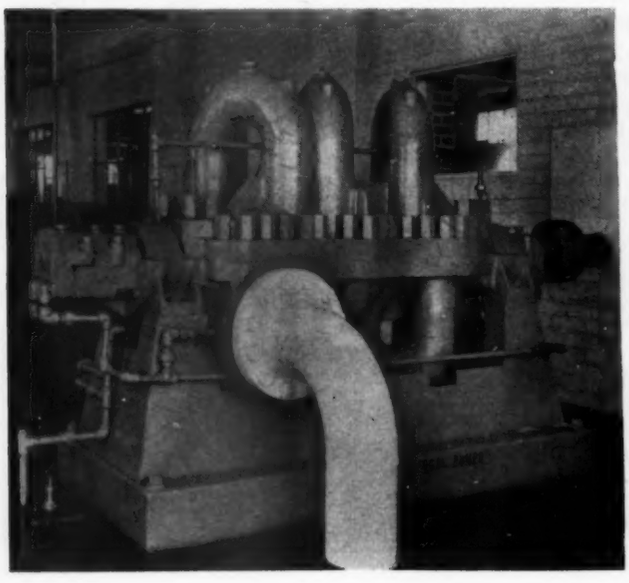
One of the important features of this entire operation is its great flexibility. Currently the engines are operating on the Duafuel principle burning natural gas with a small quantity of pilot oil to initiate combustion. They are, however, convertible for operation on natural gas with spark ignition, which allows Phillips a great latitude of operation.

These engines incorporate an intercooler and the auxiliaries have been installed with sufficient capacity for converting the engines at a later date to Supairthermal operation. This will provide 30 per cent additional power when increased capacity is desired.

Cooling of the jacket water on the engines is accomplished by a pipe line heat exchanger using the products as a cooling medium. This exchanger, installed on the suction side of the pump, cools the water from the engine to 90 F, at which temperature it is pumped to the intercooler. This intercooler, of the two-pass type, then reduces the intake manifold air temperature from the turbocharger to 105 F, 35 F less than the normal for a low-pressure supercharged engine. This permits the engine rating to be increased 10.5 per cent. Constant pressure is maintained by a surge tank placed ahead of the water pump.

Engine speed is governed by a Woodward Type PG governor, which is pneumatically controlled by air pressure from a controller actuated by suction pressure on the pipe line pump. With this system a variable rate of flow is controlled automatically. * * *

Each engine on the new Phillips Products Pipe Line drives a United Iron Works six-stage centrifugal pump.



Exhaust side of 1210-hp diesel engines at Sharpe station. Intercooler and piping are directly below exhaust header.

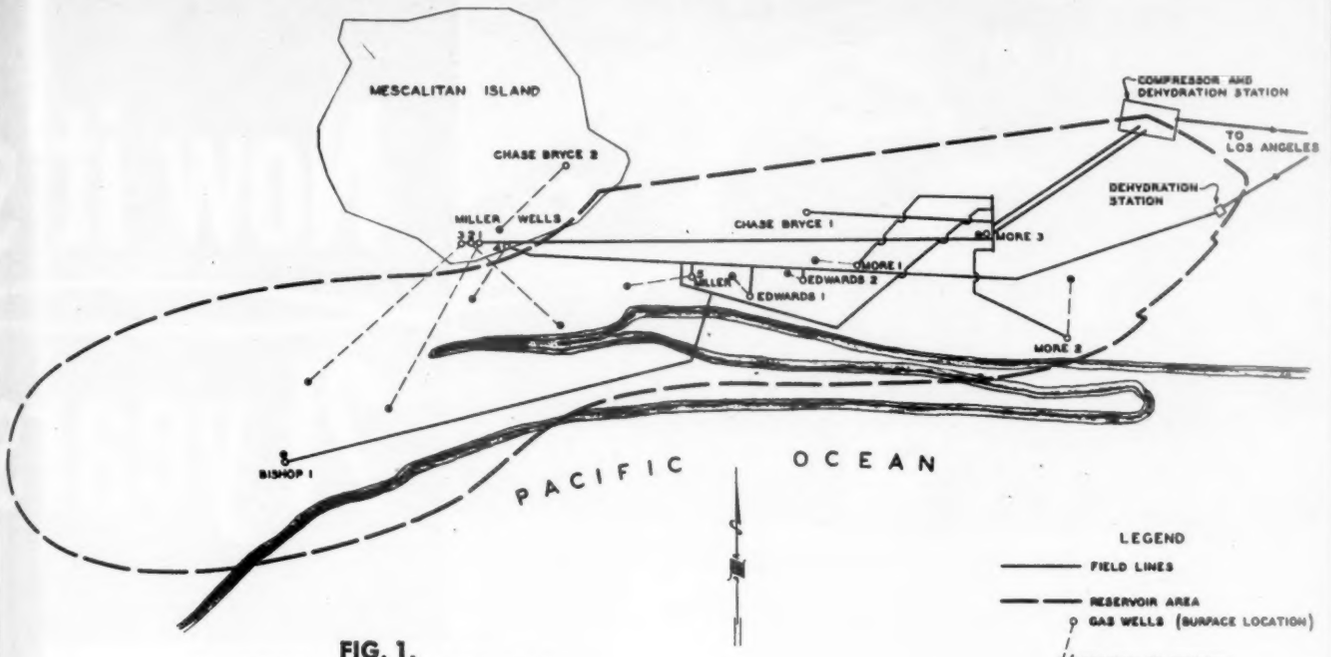


FIG. 1.
LA GOLETA GAS STORAGE FIELD
Principal facilities.

Operation of La Goleta Gas Storage Field†

With a daily deliverability of 350,000,000 cu ft, field is great asset in supplying peak requirements for Southern California

RAYMOND W. TODD*

Most people associated with the natural gas industry know something of the La Goleta underground gas storage field. The importance of the La Goleta gas storage field has steadily increased since the start of storage operations in 1941 until at present the field has a daily deliverability of 350,000,000 cu ft of gas per day and a working storage capacity of 14.4 billion cubic feet.

The La Goleta dry gas field is 8 miles west of the city of Santa Barbara, about 105 miles northwest of Los Angeles. The California coastline runs west by north from Los Angeles. The field was originally discovered by General Petroleum Corporation in August 1929, when a well being drilled by this company on the More Ranch property in exploration for oil blew out from a depth of 4533 ft. Pitot tube readings indicated that the well blew at a rate of 60,000,000 cu ft per day. When brought under control the shut-in wellhead pressure was 1700 psi. This well, known as More No. 1, was subsequently redrilled and completed at a depth of 4273 ft, whereupon the initial production test was measured at 58,000,000 cu ft per day. A second well, More No. 2, was started in October 1929, and blew out when the gas sand was encountered. It sanded up and was redrilled to completion in the gas sand.

More No. 3, also drilled by General Petroleum, was begun in August, 1930. This well was drilled to a depth of 5930 ft in search for oil, but after extensive testing it was plugged back and completed as a gas well. The gas sand encountered was 350 ft. thick.

In 1933 the Standard Oil Company of California drilled two wells on the adjoining Chase Bryce property. One well was completed as a gas producer, while the other was outside of the field limits.

Shell Oil Company, in 1934, drilled to a depth of 6508 ft in the search for oil in its Bishop No. 1. No oil was found and the well was plugged back and completed in the gas sand, which was found to be 305 ft thick at this location.

Thus, after five years of exploration oil had not been discovered; however, five gas wells had been completed and the operators had turned to the sale of natural gas.

The first gas deliveries were made from the field in 1931 and from then until the fall of 1941 a total 15.3 billion cubic feet of gas was produced in the field, which resulted in the well-head pressure dropping to 1440 psi. This gas was used by the utility companies in Southern California to meet the peak load requirements.

During this period of gas production field records showed that the gas produced per pound of reduction in reservoir pressure was steadily increasing, thereby indicating that water encroachment was occurring in the field. This, together with an increasing demand for peak load gas to supply the needs of Southern California, resulted in two definite conclusions. First, that the dry gas

†Presented before the Natural Gas Department, American Gas Association, Los Angeles, California, May 12 and 13, 1952.

*Chief Engineer, Pacific Lighting Gas Supply Company.

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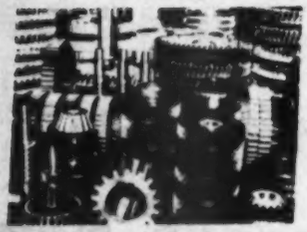

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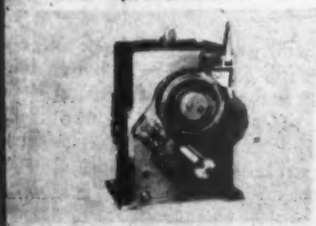

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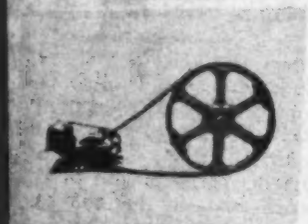

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reserves of La Goleta field would soon be depleted and second, if the use of the reservoir for storage operations was delayed until the major portion of the gas had been produced. the encroachment of edgewater would by that time be so extensive that the use of the reservoir for gas storage would be impractical. Therefore, in the summer of 1939 arrangements were made for tests to determine whether La Goleta could be utilized for the storage of natural gas. A small compressor station was constructed and several hundred million cubic feet of gas were injected in the field. These tests showed that the reservoir sand had sufficient permeability to allow the injection of gas and that a satisfactory pressure volume relationship existed. Therefore, negotiations were inaugurated for the purchase of the surface and mineral rights in the proposed storage zone.

Acquisition of Field

Although it would have been desirable to obtain options for the simultaneous purchase of all property and rights to be acquired, it was concluded that this could not be done within a sufficiently short period. Therefore, it was necessary to resort to the purchase from one owner after another in succession.

At the inception there were five groups of land owners and three oil companies who had major and substantial interests in the proved portion of the field. Each oil company had an existing oil and gas lease under which the gas producing wells had been drilled and operated. Where possible the Pacific Lighting Gas Supply Company acquired from the land owners and leaseholders the complete ownership from the surface to the bottom of the gas zone. Where not possible, the company, either by purchase or contract obtained rights to all remaining gas in place in the Vaqueros zone and the right to store and withdraw gas, leaving to the owner other mineral rights and surface rights. The conveyances for the gas and the storage rights in the reservoir provided specific protective measures with which the land owner or his lessee had to comply if in the future they desired to drill through the gas reservoir. Briefly, these measures specify the weight of mud to be used when drilling through the reservoir and that casing be set from the surface to the depth of 100 ft below the bottom of the reservoir and cemented from that point to 500 ft above the top of the reservoir. In addition to the drilling requirements, specific requirements were set forth for procedures to be followed in abandoning any well that had penetrated the reservoir.

The acquisition of the field and the area surrounding it was complicated by widely divided interests, various forms of conveyances of minerals and oil rights, and the division of ownership by inheritance. Within an 18-month period, however, the company, a non-public utility operating without the right of eminent domain, had acquired sufficient title to the various interests to assure it of control of the field.

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Geology

The gas zone, from which gas had been produced and in which storage operations were subsequently carried on, is commonly known as the "Vaqueros" zone. It is of Miocene Age and is the only productive horizon in the field. The reservoir is an anticline, trending east and west, and blocked on the northerly extreme by a major fault system, commonly referred to as the More Ranch fault. The reservoir sand is overlaid by a thick series of Miocene shales, which have proved a very effective seal for the reservoir. The sand is coarse, consisting of quartz grains that are angular with fairly sharp edges, and containing practically no silt. Analyses of some samples from the sand cores show an average porosity of 26.2 per cent and a wide variation of permeability, the average after the elimination of extremes measuring 243 millidarcys. Core samples of the sand were analyzed for oil saturation and were found to contain less than 1/10 of 1 per cent of liquid hydrocarbons. The top of the zone varies from a known minimum of 3830 ft to a maximum depth of 4207 ft below sea level, with a maximum known thickness of 377 ft. The minimum thickness of the sand as penetrated by any of the wells is 32 ft, while the average thickness of the zone developed in all wells drilled to date is 223 ft. The wells drilled by the company into the zone have not been drilled to the bottom of the gas zone as earlier exploration by the oil companies indicated that underlying the gas zone is the Sespe formation, which is wet. In drilling additional gas wells we have been cautious not to drill into this wet zone. Thus the average thickness of the gas sands penetrated by the wells is not a true indication of the average reservoir thickness. In view of the high permeability of the reservoir sand, satisfactory well production can be achieved without drilling the full sand thickness.

Since the discovery of the field 10 non-productive wells have been drilled by other companies at various times in the surrounding areas. From the most easterly producing well in the field to the most westerly is approximately 5500 ft and likewise from the most northerly well to the most southerly is approximately 1600 ft. Although these distances do not define the exact productive limits of the structure, from them and the data compiled through other known geology in the area, the field itself is deemed to cover an area of less than 300 acres. To be sure of complete control of the entire structure, mineral and storage rights in the Vaqueros zone has been obtained over an additional area of 1720 acres surrounding the field. The approximate limits of the reservoir are indicated on Fig. 1.

From data compiled during the production of gas prior to storage operations, and from the reservoir pressure volume relationship during the early stages of storage operations, the volume of the gas in the reservoir at the start of storage operations in 1941 was calculated to be almost 38 billion cubic feet. Adding the 15.3 billion cubic feet of gas produced prior to the start of storage operations the estimate for the original reservoir content is 53.3 billion cubic feet.

Field Facilities

Soon after the discovery of La Goleta field in 1931, transmission facilities were installed to deliver to the Los Angeles area the gas produced from the field. These facilities had a capacity of 65,000,000 cu ft a day when operated at a maximum pressure of 450 psi. Under normal operating conditions the five gas producing wells that had been drilled by the major oil companies had a total combined withdrawal capacity of approximately 100,000,000 cu ft a day. By early 1941 the installation of the permanent compressor station had been completed. This station operated with an intake pressure of 300 psi and had capacity to inject 28,000,000 cu ft a day at maximum discharge pressure. The 16-in. transmission line installed in 1931 to deliver Goleta gas to Los Angeles was also used to deliver injection gas to Goleta from the coastal fields near Ventura.

The compressor station, field pipe line facilities, and the injection and withdrawal wells drilled by the company were designed to operate at a maximum pressure of 2500 psi, in accordance with Division 1, Section 2, Gas and Air Piping of the ASA Code for Pressure Piping. This pressure was approximately 600 psi more than the maximum pressure necessary to inject the gas into the reservoir at the original static reservoir pressure. It was contemplated at the time these facilities were installed that ultimately gas might be stored at a pressure in excess of the original reservoir pressure and facilities were designed accordingly. The wellheads, valves, flow beans, and other equipment on the original wells that were not designed for the 2500 psi service were replaced with equipment that met the above specifications.

To remove moisture from the gas, picked up during storage, the gas was cooled by expanding from well pressure to 450 psi. Accurate control had to be maintained on this system in order to eliminate possible formation of hydrates during the cooling phase.

Performance of the field during injection and withdrawal in 1941-42 and 43 verified the conclusions drawn from the results of the tests made in 1939. With the continued rise in demand for peak gas in the Southern California area, necessary additional facilities were installed to increase the withdrawal capacity of the field to 180,000,000 cu ft a day and to increase the injection capacity to approximately 70,000,000 cu ft a day. An additional 1800 hp was installed in the injection plant and two wells were drilled. These facilities were completed in 1945. To deliver this additional volume of gas to the Los Angeles area it was necessary to install a 16-in. transmission pipe line between Goleta and Ventura.

Heretofore Goleta gas had been re-

25 YEARS' SERVICE IN A TIDAL MARSH

—no sign of corrosion!

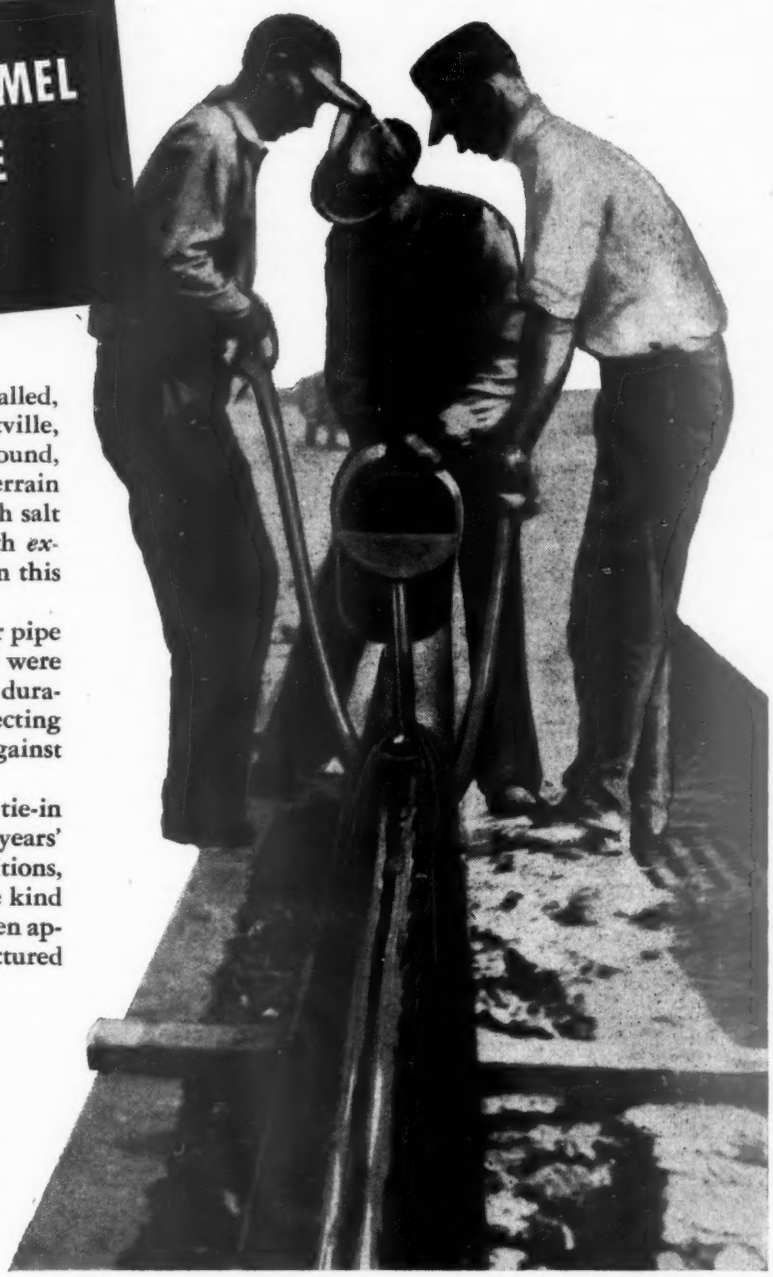
BITUMASTIC® ENAMEL PROVIDED THE PROTECTION

IN 1926, a 6-mile, 8-inch gas pipe line was installed, extending from Atlantic City to Pleasantville, N. J. This line was laid about two feet underground, in land known locally as "the meadows." The terrain is tidal marsh and high tides flood the land with salt water. No steel pipe line, unless provided with *exceptional* protection, could possibly last long in this corrosive soil.

The owners knew this and therefore had their pipe line protected with Bitumastic Enamel. They were influenced, to a great extent, by the fact that this durable enamel had already proved its value by protecting ships and large-diameter steel water lines against corrosion.

In 1951, a pipe section was removed so that a tie-in could be made with another pipe line. After 25 years' exposure to tidal marsh and sea-water conditions, there wasn't a sign of corrosion. This shows the kind of protection Bitumastic Enamel gives, even when applied by the old-fashioned manual method pictured here.

Today, of course, gas and oil pipe lines are cleaned, primed, coated and wrapped mechanically. Further—improvements have been made in Bitumastic Enamels in the last 25 years. Give your next pipe-line project *lasting* protection against corrosion by specifying Bitumastic Enamels. Your Koppers representative will give you complete details and estimates.



Photograph made in 1926 shows gas pipe line (Atlantic City—Pleasantville) being coated with Bitumastic Enamel. A single coat of enamel was applied by the "Sling Method" to a minimum 1/16" thickness. In 1951, a pipe section was removed so that a tie-in with another line could be made. An examination revealed no sign of corrosion.

KOPPERS BITUMASTIC ENAMELS
REG. U.S. PAT. OFF.

KOPPERS COMPANY, INC., Tar Products Division, Dept. 951-T, Pittsburgh 19, Pa.

DISTRICT OFFICES: BOSTON, CHICAGO, LOS ANGELES, NEW YORK, PITTSBURGH, AND WOODWARD, ALA.

compressed at Ventura for delivery to Los Angeles. To eliminate this compression the new facilities were designed to operate with an initial pressure at Goleta of 1000 psi. This increased delivery pressure precluded the partial dehydration of gas through expansion cooling and, therefore, a diethylene glycol dehydration plant was installed. This plant had a capacity of 200,000,000 cu ft a day and was designed to operate at 1050 psi pressure.

Subsequent to this increase in capacity the continuing rise in demand for peak load gas necessitated the installation of additional injection and withdrawal facilities until at present the injection plant has a total of 3750 hp, which permits it to inject gas at the rate of 90,000,000 cu ft a day with an intake pressure of 950 psi. The withdrawal facilities have a capacity of 350,000,000 cu ft a day. Fig. 2 shows intermittent increases in capacity as they have occurred. The small decreases shown in the injection capacity in 1943 and 1946 were the result of a portion of the injection facilities being used for recompression of transmission gas.

In June 1952, one of the units now used for recompression of transmission gas will be converted to injection service, which will increase the plant injection capacity to an average of 108,000,000 cu ft a day.

There are 12 wells drilled in the field, 11 of which are currently used for the injection and withdrawal of gas. Bishop No. 1, one of the original five wells drilled in the field, is now used as a control well for observation of pressures during the injection and withdrawal periods.

Referring to Fig. 1, the wells drilled by our company are Miller 1, 2, 3, 4, and 5, and Edwards 1 and 2. These wells were all directionally drilled. The dotted line indicates the offset of the bottom of the hole from the wellhead location. Directional drilling has been necessary as a portion of the field adjoins the Santa Barbara airport. Derricks have to be located so as not to interfere with air operations. To eliminate possible well interference and to maintain as uniform a reservoir pressure as possible, the bottom locations of the wells have been spaced a minimum distance of 400 ft apart.

In contrast to the five original wells in the field, drilled in the search for oil and later converted to the production of gas, the seven wells subsequently drilled by the company were drilled to a known objective and were designed and completed for the maximum production of gas.

One problem commonly encountered in drilling of gas wells into very porous sands is that the sand is mudded off by the rotary mud remaining in the hole for a relatively long period of time. To eliminate this possibility, wells drilled by the company were drilled to the top of the gas storage zone where 8⅝-in. casing was set and cemented. Following this operation, drilling into the reservoir is done in as short a time as possible, and electric logs run to delineate the sand strata. The perforated liner is then hung and a 2-in. tubing run to within a few feet of the bottom of the liner. Following the installation of the wellhead the well is brought into production. Such an operation results in drilling mud coming in contact with the reservoir sands for a period of only about five days. This procedure has proved very satisfactory as all wells drilled by the company has produced on test at a rate of at least 50,000,000 cu ft a day and Miller No. 1, drilled in 1943, on test produced at a rate of 145,400,000 cu ft a day. We believe this to be the largest controlled production ever recorded from any well in California. During normal operations considerably lower rates are used in order to eliminate the possible cutting out of liner perforations or wellhead equipment. The field piping system consists generally of two independent lines connecting the wells to two dehydration plants. These facilities are separated approximately 500 ft so that the entire output of the field would not be lost in the event of a pipe line or plant outage. The first dehydration plant installed was designed for an ultimate capacity of 250,000,000 cu ft. When the withdrawal requirements of the field exceeded this capacity, a second plant was planned with an additional 250,000,000 cu ft capacity. A portion of this plant has been completed and at present has a capacity of 100,000,000 cu ft a day.

Annual inspections are made of the injection plant, field, and wellhead facilities to detect any erosion or corrosion that might occur in the high pressure facilities. These inspections include the removal and internal inspection of various portions of the high pressure system. Both the main injection plant and the two dehydration plants are equipped with automatic shutoff and blowdown valves situated outside the plant area. These systems are designed so that in the event an accident occurs

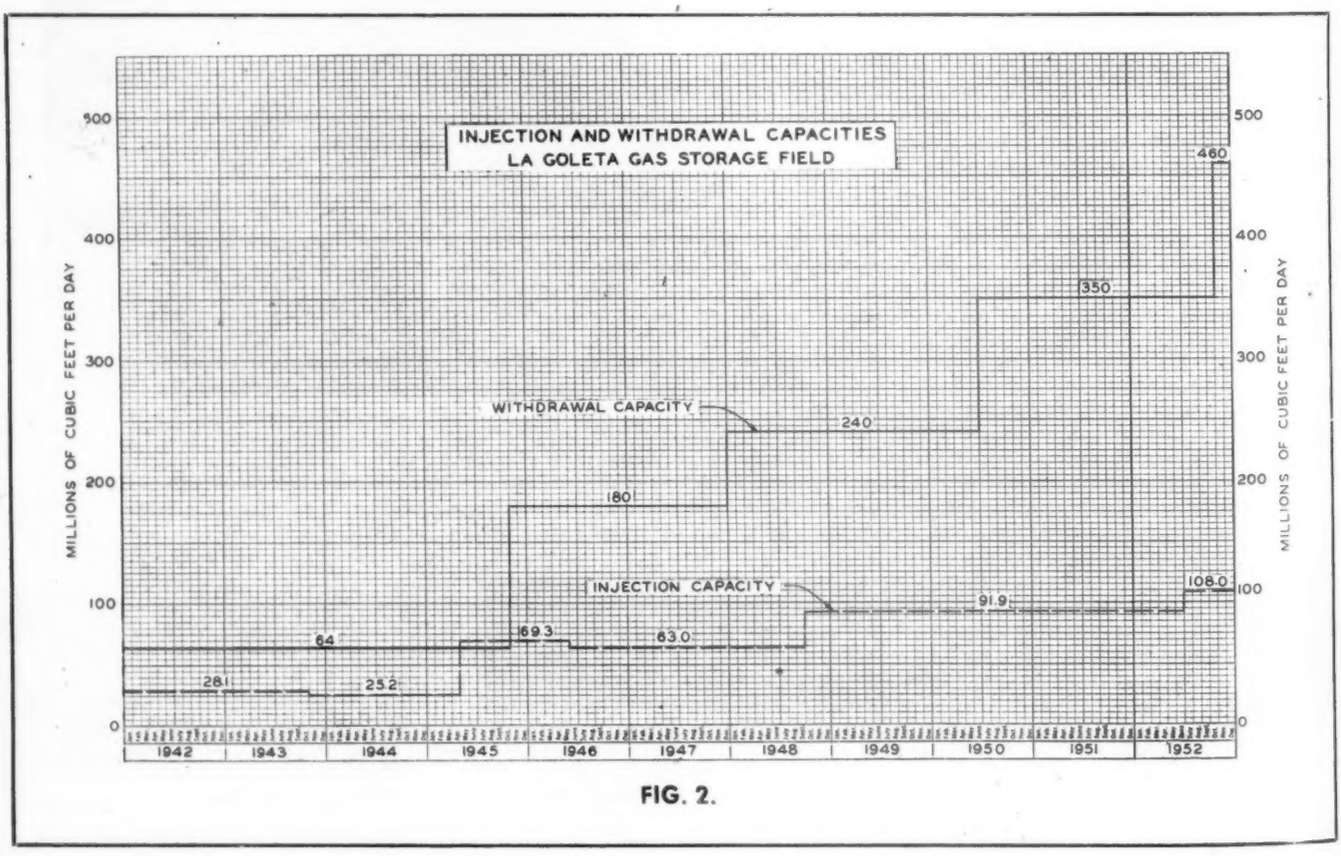


FIG. 2.

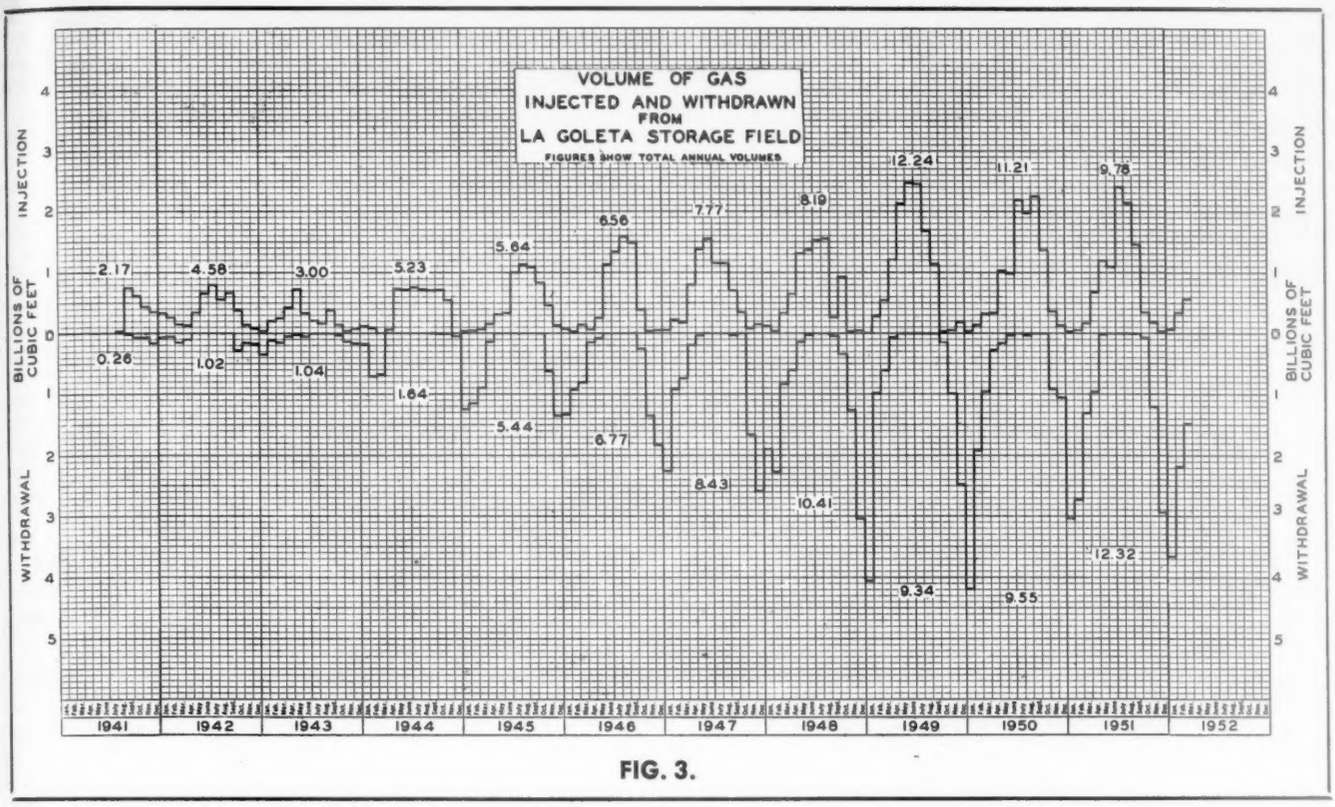


FIG. 3.

in the plant area the shutoff valves close and the blowdown valves automatically open. This system also automatically shuts down any main compressor units that might be operating at the time of the accident.

Transmission Lines

The principal transmission facilities between La Goleta field and the Los Angeles area now consist of a 16-in. and a 20-in. and 22-in. pipe line that operate with an initial pressure of 1000 psi and have a capacity of 338,000,000 cu ft a day. These facilities are owned by the Southern California and Southern Counties Gas Companies.

Field Operation

The storage of gas in La Goleta field was begun in August, 1941. During the remainder of that year 2.17 billion cubic feet of gas were injected in the storage zone. In 1942, the first full year of operation, 4.58 billion cubic feet of gas were injected while 1.02 billion cubic feet were withdrawn. Fig. 3 shows the total volume of gas injected and withdrawn each year since beginning of operations. These volumes are somewhat greater than the net annual volumes injected and withdrawn, as variable weather, principally during the spring and fall of each year, results in some intermittent injection and withdrawal of gas. In 1942-43 and 44 the volume of gas injected each year was considerably greater than that withdrawn in order that the reservoir pressure be increased as fast as possible to prevent further loss of reservoir space to water encroachment. The greatest volume of gas injected during a single season was in 1949, when a total of 12.24 billion cu ft was injected. During this last winter of 1951-52 we have experienced the largest withdrawal to date, when up to the first of May, 1952, 12.17 billion cu ft had been withdrawn.

Fig. 4 shows the net accumulated volume of gas in storage, together with the field wellhead pressure. It emphasizes the buildup of stored gas during the early years of storage to offset the gas that had been produced prior to storage operations. By the fall of 1946 the net accumulated volume of gas in storage was 14.4 billion cu ft and the corresponding field wellhead pressure was 1845 psi, approximately 125 psi higher than the original field pressure. Even with the higher reservoir pressure this net volume of stored gas is considerably less than the 15.3 billion cu ft that had been produced prior to storage operations. This discrepancy is generally attributed to the loss in reservoir volume from edgewater encroachment that took place during the extended period of low reservoir pressure prior to the storage operations.

The pressure volume relationship in the reservoir during the latter part of this period was approximately 33,600,000 cu ft of gas per pound of decline in reservoir pressure. Operations since 1946 have resulted in a pressure volume relationship of approximately 27,400,000 cu ft of gas per pound change in reservoir pressure. The reservoir pressure volume relationship from 1946 to present is shown on Fig. 5. The curves for each year follow the same general pattern and with very little hysteresis, because of the high permeability of the reservoir sand. From 1946 on a relatively stable condition existed in the reservoir due to the fact that the average pressure during the year was approximately that of the original reservoir pressure prior to the production of any gas. With the net accumulated amount of gas in storage ranging from 14.4 to 14.1 billion cubic feet at the end of each annual injection period, in 1946, 47, 50, and 51 there was less than 20 psi variation in the resulting field wellhead pressures. The refinery strike in 1948 curtailed the volume of gas available for storage during that year.

The slight deviations that occur along the curves are the result of unequal pressures in the reservoir during periods of withdrawal and injection. Therefore, during those periods the deadweight pressures recorded at the control well, Bishop No. 1, do not indicate the true average reservoir pressure. At the conclusion of each annual injection period, however, the field is shut in for a period of two weeks prior to taking pressure readings. This allows the reservoir pressure to equalize, which results in a close correlation of these points on the curve.

To eliminate high pressure differentials in the reservoir, the flow of gas is regulated to and from the different wells in the field. Wells completed in the highly permeable sands are assigned higher injection and withdrawal rates than are the wells completed in the sands of lower permeability. During maximum rates of injection there is from 50 to 60 psi pressure drop in the field piping system between the discharge of the compressor station and the wellhead, and approximately 60 psi pressure drop between the wellhead pressure during injection and the shut-in pressure. During periods of withdrawal at rates ranging between 35,000,000 and 40,000,000 cu ft per well, the wellhead pressure drawdown is approximately 180 psi.

As previously stated, present withdrawal capacity of the Goleta field is

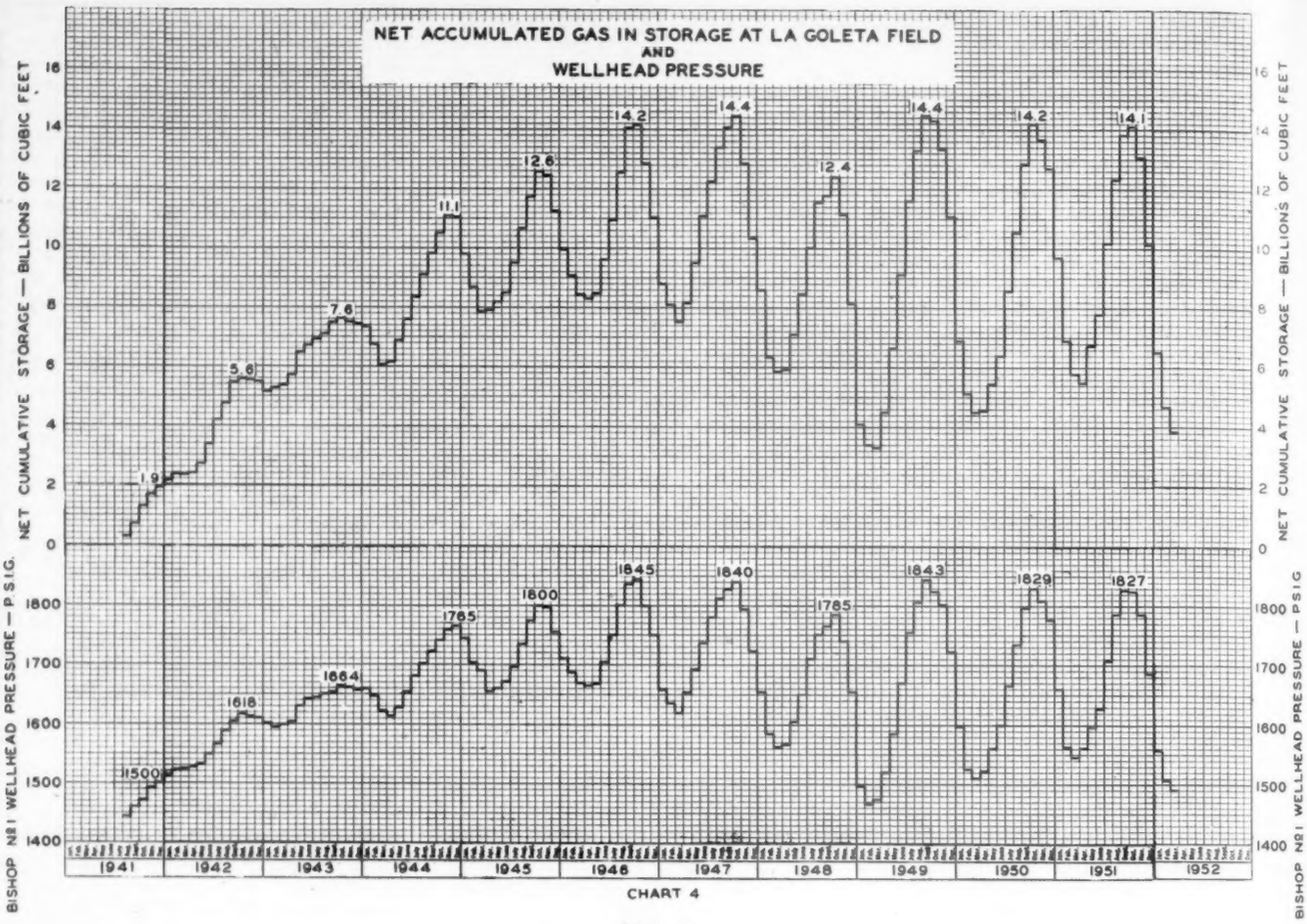

NET ACCUMULATED GAS IN STORAGE AT LA GOLETA FIELD
AND
WELLHEAD PRESSURE
NET CUMULATIVE STORAGE — BILLIONS OF CUBIC FEET
BISHOP NO 1 WELLHEAD PRESSURE — P.S.I.G.
1.9
5.6
7.6
11.1
12.6
14.2
14.4
12.4
14.4
14.2
14.1
1500
1618
1664
1765
1800
1845
1840
1785
1843
1829
1827
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
CHART 4

FIG. 4.

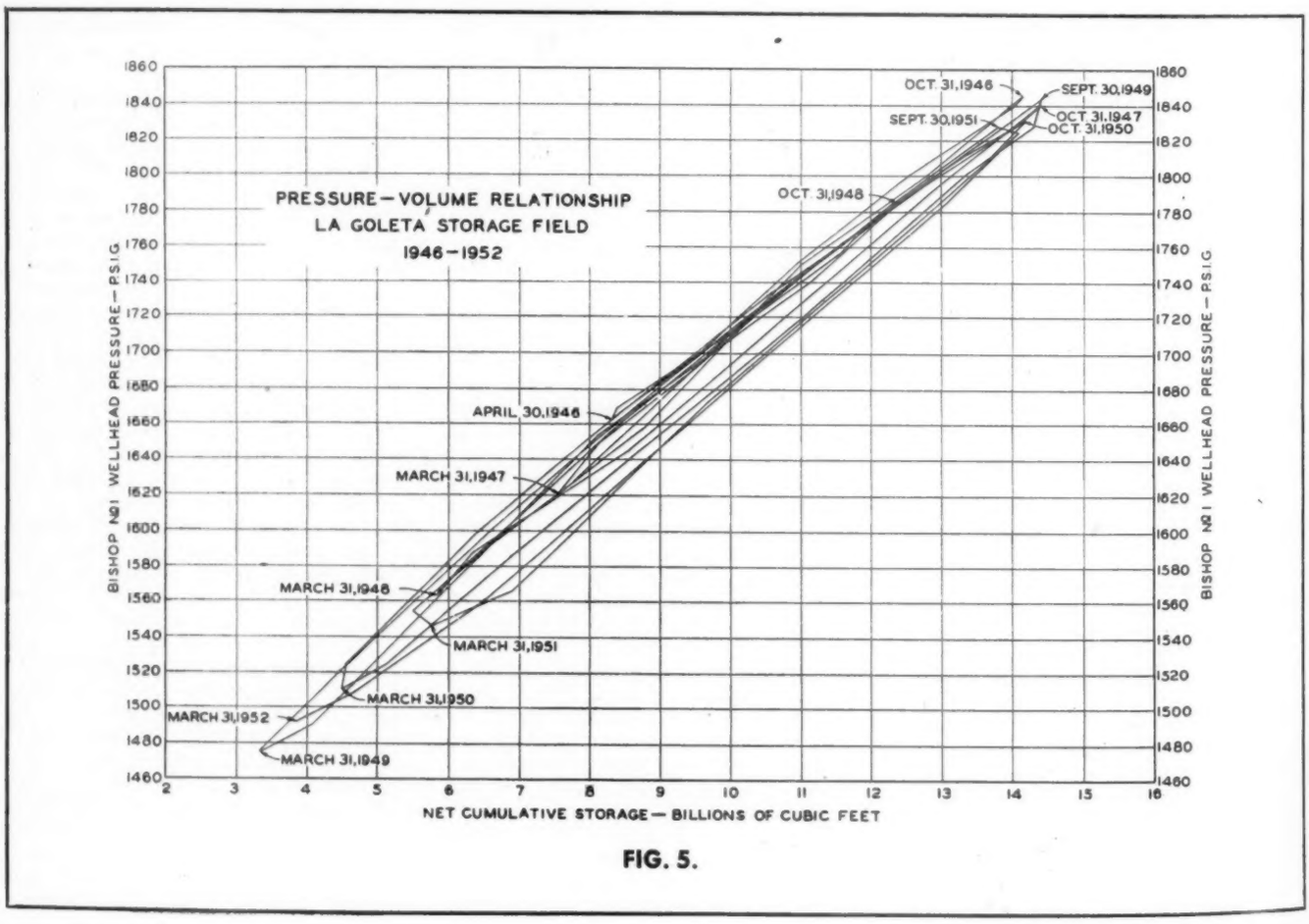

PRESSURE — VOLUME RELATIONSHIP
LA GOLETA STORAGE FIELD
1946 — 1952
BISHOP NO 1 WELLHEAD PRESSURE — P.S.I.G.
NET CUMULATIVE STORAGE — BILLIONS OF CUBIC FEET
OCT. 31, 1946
SEPT. 30, 1949
SEPT. 30, 1951
OCT. 31, 1947
OCT. 31, 1950
OCT. 31, 1948
APRIL 30, 1946
MARCH 31, 1947
MARCH 31, 1948
MARCH 31, 1951
MARCH 31, 1950
MARCH 31, 1952
MARCH 31, 1949

FIG. 5.

350,000,000 cu ft of gas a day. We are now drilling two additional gas wells and installing additional dehydration facilities so that by the fall of 1952 the daily deliverability of gas from the field will be 460,000,000 cu ft a day. It appears that the total volume of gas withdrawn and injected each year will be gradually increase, as there probably will be increasing intermittent storage and withdrawal of gas during each year, especially during the latter part of the annual withdrawal period. This occurred this spring when, following the withdrawal of a very large volume of gas from storage, we started to inject gas during the month of March in order to replenish the volume of gas in storage to meet subsequent cold weather, which occurred during the early part of April.

Operations of La Goleta storage field have shown that it is a perfect natural gas storage reservoir with high pressure capacity for the injection and withdrawal of at least 10 billion cubic feet of gas each annual season. All gas injected remains in the reservoir available for immediate recovery. Edgewater has not encroached upon the reservoir within the range of operating pressures of the last five years. The operation of this storage field has not been complicated by the presence of oil, hydrocarbon condensates, or excessive amounts of water. The reservoir sand does not enter the wells during production, nor does it clog up during the injection. In the 24 years since the original discovery well was drilled earth movements have not damaged the wells, although the field is faulted. It seems unlikely that there will be further prospecting for oil below the Vaqueros sand, in view of the extensive deep drilling that was performed when the reservoir was first discovered, and the drilling restrictions governing drilling through the storage zone.

The rate of withdrawal of gas is not limited by the physical characteristics of the reservoir. Production capacity, for all practical purposes, is contingent only upon the number of wells that would have to be drilled and there is ample space for all that may be required. The reservoir is advantageously situated in that there is adequate supply of gas for injection purposes in the Ventura and nearby coastal fields. These advantages were not all immediately evident to those associated with the acquisition and the early development of the storage field. Nevertheless their far-sightedness and determination to acquire the field in the face of many seemingly insurmountable obstructions certainly has proved to be a great asset in supplying the peak load gas requirements for the Southern California area.

* * *

B-A Peerless Launched

One of the world's largest fresh water tankers was launched in July when Premier Leslie M. Frost of Ontario officiated at the ceremony for The British American Oil Company's new ship, *B-A Peerless*. The 620-ft tanker will carry about 125,000 bbl a trip of Canadian crude oil from Superior, Wisconsin, to B-A's refinery at Clarkson, Ontario.

MURPHY Safety Switches are...

DEPENDABLE
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WE ALSO HAVE
No. 1 — Nicolet Regular 15#
No. 2 — Nicolet Perforated 15#
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Filing Date Advanced For Line Pipe Applications

Deadline for the filing of applications for quarterly requirements of line pipe for small construction and production operations and for use in MRO (maintenance, repair, and operations) in the oil and gas industries has been advanced, it was announced by the National Production Authority, Department of Commerce.

Previously, operators were required to file their applications three months before the beginning of the quarter in which they wanted delivery of the line pipe. Now they will be required to file their applications four months in advance.

The filing date was changed through Amendment 1 to NPA Order M-46, which establishes the priorities-assistance system for the oil and gas industries.

The action requires that applications on Form PAD-26LP be filed with the Petroleum Administration for Defense on or before the first day of the fourth month preceding the calendar quarter in which delivery of materials is required.

Form PAD-26LP must be filed by an operator in all cases when his combined quarterly requirement for line pipe on other than a large-construction project totals $5000 or more. When the total is less than $5000, an operator may either file Form PAD-26LP or self-certify his delivery order in accordance with Section 7(d) of M-46.

Purpose of advancing the deadline, it was explained, is to enable the Petroleum Administration for Defense to issue authorizations for purchase at an earlier date.

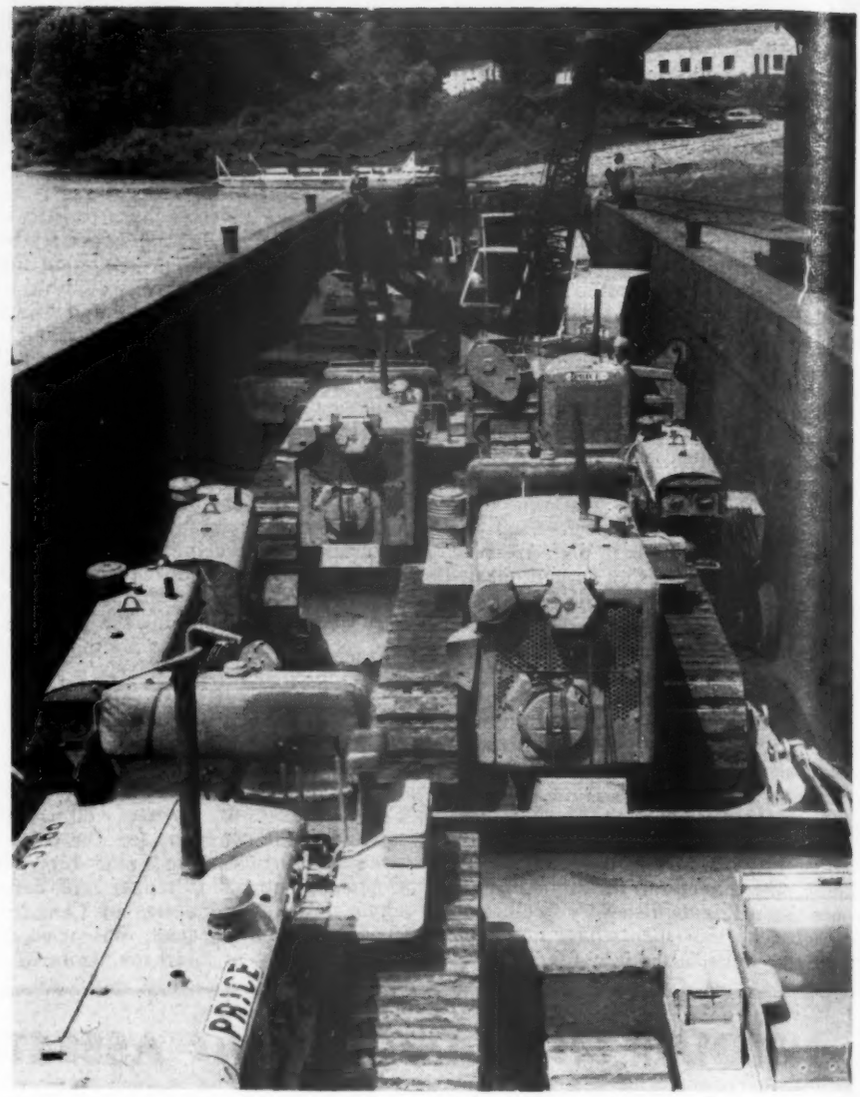
Tennessee Issues Bonds To Pay for Construction

The Tennessee Gas Transmission Company has filed a registration statement with the Securities and Exchange Commission in Washington covering an offering of $40,000,000 first mortgage pipe line bonds due in 1972, it is announced by Gardiner Symonds, president.

The bonds will be sold at competitive bidding and sealed written bids for their purchase will be invited after the SEC has allowed the registration to become effective, Symonds said.

The net proceeds from the bond sale will apply on the payment of the company's outstanding short-term notes, which were issued to provide a major part of the funds for the company's 1952 construction program. The program is expanding system capacity from about 1,200,000,000 cu ft a day to approximately 1,310,000,000 cu ft a day. New capacity being added is to care for expanded markets along the system.

The company has been authorized by the Federal Power Commission to further increase daily delivery capacity of its natural gas system to 1,515,000,000 cu ft, and to build storage facilities that will increase peak day capacity to 1,715,000,000 cu ft.



Fully loaded and ready for the long trip down river to Greenville, Mississippi, this big barge was just one of five needed by H. C. Price Company to transport its Spread Four from Fly, Ohio.

Pipeline Spread Transported 1280 Miles by Barge

For the first time in the pipe line construction industry's history, an entire "big inch" pipe line spread has been moved a total of 1280 miles by barge on the Ohio and Mississippi rivers.

H. C. Price Co.'s Spread Four was transported by this unusual means from Fly, Ohio, a short distance south of Wheeling, down-river to Greenville, Mississippi. The complete move was carried out in record time without damage to the expensive machinery.

An estimated 1500 tons of equipment were involved in the shipment. Five hopper barges, 175 ft long by 26 ft wide, were used by the Price company. At both the loading and unloading points huge derrick barges were used to lift heavy machinery from ground to barge.

Approximately three weeks were required from the time the first piece of equipment was loaded at Fly until the last piece of machinery was unloaded at Greenville. Considerable time was lost en route due to unusually severe fog and a damaged lock on the Ohio River. The shipment was handled by the Union Barge Line Corporation of Pittsburgh, Pennsylvania, which provided both the barges and the towboat "Neville".

The history-making shipment was made possible by the fact that the Price company's spread had completed a section of 30-in. pipe for the Texas Eastern Transmission Corporation near the Ohio River and was assigned to construction of a new 26-in. line for the Texas Gas Transmission Corporation, starting on the east bank of the Mississippi River near Greenville.

Platte Pipe Line Moves Offices to Kansas City

Platte Pipe Line Company, which has under construction an oil pipe line from Wyoming to Illinois, has moved from temporary headquarters in Independence, Kansas, to permanent headquarters in Kansas City, Missouri. The move was made over the Labor Day week end. The company is occupying the entire 12th floor of the Kansas City Power and Light Company Building. Millard Neptune is president of Platte.

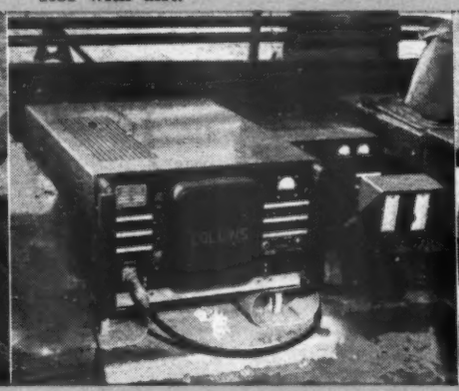
Special Delivery by Air . . .

Parachuting Signal Corps jeep containing a Collins 18S transceiver upsets on landing.

The jeep's topside cuts a neat furrow into the soft earth and packs the interior with dirt.

Truck rights the jeep. Under other field conditions this would be accomplished by several soldiers.

Protective board covering is removed and the eight-foot whip type antenna released.



Special shock mounts, a heavier dust cover and bracket reinforcements strengthened the 18S.

Radio operator (back to the camera) plugs the microphone and headsets into the transceiver.

Antenna erected and power on, radio operator tunes transmitter and makes test call.

Answer of "receiving loud and clear" proves contact successful.

With contact established, jeep leaves platform.

Tossing radio equipment from airplanes is not generally recommended as standard operating procedure . . . but in recent demonstrations the U. S. Army found the Collins 18S transceiver capable of taking such punishment.

Collins advanced Engineering and Research facilities are available to the Oil and Pipe Line industries in designing and installing electronic communications systems. Your inquiries will receive prompt attention.

For dependable electronics and aviation radio equipment, it's . . .

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COLLINS RADIO COMPANY, Cedar Rapids, Iowa

11 W. 42nd St., NEW YORK 36 **2700 W. Olive Ave., BURBANK** **1930 Hi-Line Drive, DALLAS**

H. H. Anderson

Hal Anderson Goes With Trans Mountain

H. H. Anderson, vice president and general manager of Shell Pipe Line Corporation since 1941, has retired from that company and accepted a position as vice president and general manager of the Trans Mountain Pipe Line Company, a Canadian stock company now constructing a 711-mile, 24-in. pipe line from Edmonton to Vancouver.

Holder of a BS degree in electrical engineering and MS degree in physics and mathematics, Anderson halted plans for a PhD in 1917 to join Shell as an engineer in the Coalinga field.

He became chief engineer of Shell's West Coast production department in 1925 and four years later supervised planning and construction of the 30-story Shell Building in San Francisco. In 1931 he was summoned to New York as assistant to the president of Shell Union, and the next year was made a vice president of Shell Oil Company.

Twice during the 1930's Anderson went to Washington in the cause of the oil industry. In early NRA days he spent a year as chairman of the Oil Code Authority's Labor Committee. In 1939 he went to Washington as one of eight executives selected to present the petroleum industry's story to the Temporary National Economic Committee.

Long active in affairs of the American Petroleum Institute, he has held many important positions within that organization. In 1950 the API recognized his many contributions by awarding to him its Certificate of Appreciation.

Phillips Buys Crude Oil Line From Shell

Phillips Pipe Line Company has purchased the Shell Pipe Line Corporation's all-welded, 10-in. crude oil pipe line that extends from McCamey to Brookshire, Texas, a distance of 394 miles, it was announced by K. S. Adams, Phillips chairman, and Paul Endacott, president.

This line runs roughly parallel to the 455-mile 24-in. Rancho crude oil pipe line now being constructed by Shell, Phillips and others from West Texas to the Gulf Coast.

Texas-Ohio Gas Company Litigation Settled

Texas-Ohio Gas Company has announced the settlement of several suits that grew out of differences between management of the company and a group represented by Clyde Austin, former assistant secretary-treasurer of the company. The settlement applies not only to the company itself, but also to various officers and representatives of the company who were named individually in these suits. Under terms of the settlement, Clyde Austin, trustee, receives 5000 shares of stock, and W. R. Flocks, trustee, receives 65,000 shares of stock. The balance of the total 600,000 shares is retained in control of the banking and management groups.

At the same time, Texas-Ohio Gas Company added three new members to its board of directors. The new board members are J. P. Bristow, J. Leslie Witt, and Joseph W. Hibben. Bristow was formerly vice president in charge of operations of Tennessee Gas Transmission Company and later vice president of Fish Pipe Line Construction Corporation and project manager of the construction of Texas-Illinois Natural Gas Pipeline Company. Witt is an executive of Emsco, Houston, and Hibben is a partner in charge of the Chicago office of Kidder-Peabody and Company, a New York banking firm.

The new directors are in addition to the four directors already serving who are: Frank Champion, Glenn Y. Davidson, T. B. Hoffer, and Burt Hull.

The company confirmed by a board resolution the following Texas-Ohio Gas Company officers: Frank Champion, president; Louden C. Doney, Jr., vice president and chief engineer; T. B. Hoffer, vice president; Glenn Y. Davidson, secretary-treasurer; J. Leslie Witt, assistant secretary-treasurer; Vernon B. Lowrey, counsel, and F. R. Schuetze, auditor.

Texas-Ohio Gas Company proposes to deliver gas to utilities and industrial users in the state of Ohio. In the company's hearings before the Federal Power Commission, both the attorney general of Ohio and the Public Utilities Commission of Ohio have appeared before the FPC stressing the needs of the state for additional gas supply.

Champion states that a market for the full capacity of the line is assured. The line will run approximately 1400 miles from the Rio Grande River near McAllen, Texas, where it will pick up gas from Mexico on a line between the two countries, to a point in eastern Ohio. The total cost of the project will be upward of $200,000,000, which a syndicate headed by Kidder-Peabody and Company plans to underwrite.

In addition to the new directors who have at this time taken office, announcement is made of the appointment of William A. Baker, Jr., as chief geologist of the company. Baker, who has been in charge of the company's Mexican interests, is now in charge of all geological operations.

The company states that the commitment of Petroleos Mexicanos to Texas-Ohio of large gas reserves in the State of Tamaulipas, Mexico, has been confirmed on the public record of the Federal Power Commission through the highest diplomatic channels, by official communication from the Mexican Ambassador in Washington through the American State Department.

Baker has completed presentation of geology on these Mexican commitments to the FPC. He and his staff are now preparing geology on domestic gas for presentation to the commission at an early date. D. B. MacDaniel is in charge of gas procurement.

The company's contract for Mexican gas is for 200,000,000 cu ft a day, backed by reserves for 20 years, it is stated. The company has filed with the FPC commitments for Texas totaling 350,000,000 cu ft of gas a day with 20 year reserves.

Champion, president of Texas-Ohio, expressed himself as well pleased with present developments, and confident that the affairs of the company are now in excellent shape.

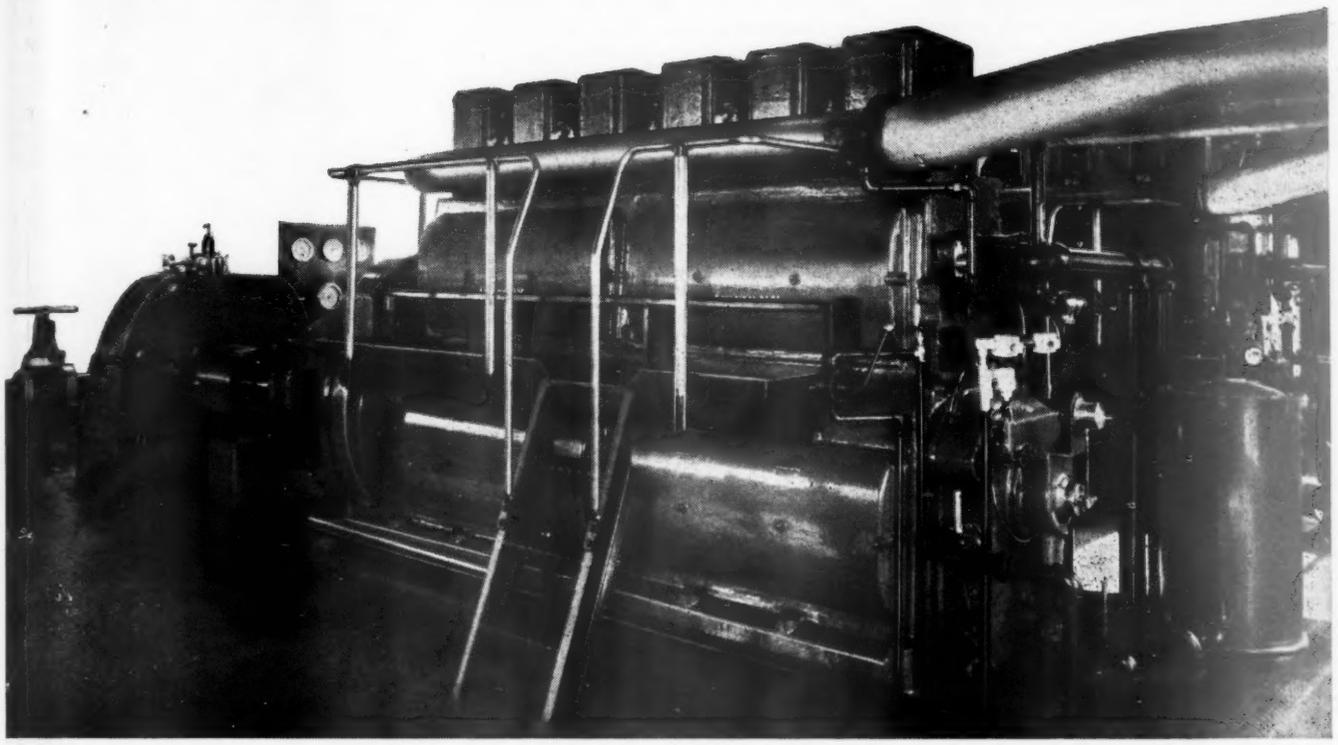
Problems of Small Gas Companies to Be Studied

The executive board of the American Gas Association has authorized the appointment of a "Committee on Special Problems of Smaller Gas Companies." This committee will review various association activities and make recommendations for any changes that would benefit the smaller companies. It also will serve as a representative committee to see that the interests of the smaller companies, those of 500 employees or less, are properly taken care of at AGA.

W. Lee Woodward, president, Zenith Gas Company, Inc., Alva, Oklahoma, has consented to serve as chairman of this important committee. Other executives serving on the new committee include: R. E. Crawford, president, Minnesota Valley Natural Gas Company; F. P. Dicus, president, The Nebraska Natural Gas Company; C. J. Dodds, vice president, Kansas Public Service Company, Inc.; David H. Frazier, Jr., president, Battle Creek Gas Company; Edward M. Hahn, president, Kokomo Gas and Fuel Company, and Hansell Hillyer, president, South Atlantic Gas Company.

Other committee members are: J. H. Isherwood, vice president and general manager, North Penn Gas Company; Stewart Matthews, president, Bellingham Gas Company; Stephen V. O'Lenic, president, Chattanooga Gas Company; E. F. Putnam, president, The Greenwich Gas Company; W. W. Rusk, Clayton Gas Company, and A. H. Stack, president, The Tampa Gas Company. Also Carl M. Stephens, president, Council Bluffs Gas Company; Thomas H. Sykes, executive vice president, Suffolk Gas Corporation, and John A. Weiser, executive vice president, The Newport Gas Light Company. Thomas J. Stanley, AGA headquarters, is secretary of the new committee.

at the Anthony Station of Magnolia Pipe Line . . .



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Wallace Elevated by Oklahoma Natural Gas

P. K. "Doc" Wallace, assistant to the general superintendent of the Oklahoma Natural Gas Company, has been named to the position of general superintendent, it is announced by Jos. Bowes, president.

Wallace succeeds Carl E. Cloud, who has resigned to become president of the Midsouth Gas Company, Little Rock, Arkansas.

The new general superintendent is a native Oklahoman, born in Indian Territory in what is now Hughes County. His father was Dr. V. M. Wallace of Morris, Oklahoma.

After receiving his public and high

P. K. Wallace

school training in Morris, Wallace attended Oklahoma University, Oklahoma A. & M. College, and Baylor University. He was employed by Oklahoma Natural Gas Company in 1926 at Morris, where he worked as laborer, timekeeper, and foreman.

Late in 1928, when Oklahoma Natural acquired the gas properties of the Oklahoma Gas and Electric Company, Wallace was transferred to Oklahoma City where he received varied experience in several departments. In 1934 he was made chief operating clerk.

He became assistant superintendent of the Oklahoma City district in 1941, and three years later he joined the Tulsa general office staff as assistant to the general superintendent. In this capacity he has headed the general distribution activities of ONG for the last 8 years.

In addition to his wide experience with Oklahoma Natural, Wallace has been active in gas industry circles, having served on various committees of the American Gas Association, Southern Gas Association, and Oklahoma Utilities Association.

Tennessee Gas Applies For Rate Increase

Faced with rising costs, the Tennessee Gas Transmission Company has filed an application in Washington, D. C., to increase its rates approximately $16,750,000 per year effective September 15, the pipe line firm has announced at its headquarters in Houston, Texas.

Sharp increases in the field price of natural gas purchased by the company make up 85 per cent of the company's cost increases, the application stated. The company has entered into new gas purchase contracts that already have increased 1952 gas costs substantially, but the major increase becomes effective February 1, 1953, the application pointed out.

Tennessee Gas sells gas at wholesale for distribution principally in the Appalachian area including Tennessee, Kentucky, Ohio, West Virginia, Maryland, and parts of Pennsylvania and New York, as well as in New England. It sells lesser amounts for distribution in Texas, Louisiana, Mississippi, and Alabama.

Contract for 52 Miles Of 16-in. Pipe Awarded

Interstate Oil Pipe Line Company announces the letting of a contract for the construction of approximately 52 miles of 16-in. crude oil trunk line between the company's Sunset, Louisiana, pump station in St. Landry Parish, and Anchorage Terminal, West Baton Rouge Parish.

The contract was awarded to Houston Contracting Company, Houston, Texas. Construction is expected to get under way late in August, with completion expected during November of this year.

The new line will replace Interstate's existing combination 8 and 10-in. trunk line between Sunset station and Anchorage Terminal.

Carl E. Cloud

Carl Cloud Becomes President of Midsouth

Carl E. Cloud, general superintendent of the Oklahoma Natural Gas Company, has resigned to accept the position of president of the Midsouth Gas Company of Little Rock, Arkansas.

Cloud, who is a native of Hobart, Oklahoma, and a graduate of Oklahoma University in natural gas engineering, has been with Oklahoma Natural since June, 1934.

His early experience with Oklahoma Natural included a variety of operating and construction work in the operating and gas measurement departments. In 1937 he was assigned to the general superintendent and vice president as an engineer.

In September, 1938, Cloud became district manager of the Kansas properties then owned and operated by Oklahoma Natural Gas Company.

Upon the sale of Oklahoma Natural's Kansas property in September, 1942, Cloud went to Washington, D. C., where, on loan from Oklahoma Natural, he served with the Office of War Utilities of the War Production Board as area chief of the Gulf Coast Region.

He returned to Oklahoma Natural in March, 1944, as general superintendent.

Active in gas industry work, Cloud has served on the Transmission Committee of the American Gas Association, and is presently a member of the Distribution Management Committee of the Southern Gas Association. He is past chairman of the Transmission Section of the Southern Gas Association and served as vice chairman and chairman of the Gathering, Processing and Transmission Section of the School of Gas Technology of Texas A. and I., Kingsville, Texas, in 1950 and 1951.

Cloud is a member of the board of directors of the Oklahoma Utilities Association and is past chairman of the Natural Gas Section of that organization.

He is a registered professional engineer in Kansas, and a member of the Tulsa Engineers Club.

New Company Formed By Well-Known Pipeliners

Three men long identified with the pipe line industry, have recently organized a new company under the name of Lone Star Constructors. Pooling their combined total of 65 years' pipe line experience, Paul R. Halbert, J. K. Little, and N. K. McFarland have opened offices on the tenth floor of the Mercantile National Bank Building, Dallas, Texas.

McFarland stated that the company was organized to construct cross-country pipe lines, pipe line river crossing projects, and to take up and recondition old pipe lines.

Halbert has been in the pipe line business for more than 25 years, Little 15, and McFarland 22 years.

Lone Star's equipment is capable of handling projects of any diameter-size pipe. Headquarters of the company is conveniently located in Dallas to serve central and western portions of the United States.

Pipe Shortages Delay New Lone Star Lines

Pipe shortages directly attributable to the recent steel strike have forced Lone Star Gas Company to delay laying more than 130 miles of major transmission and gathering lines especially designed to meet increased customer demands anticipated this winter.

This condition was reported by Lone Star President D. A. Hulcy of Dallas, who said that the two pipe line construction projects represented in the 130 miles had been set for completion in September and October. He added that numerous other transmission and distribution lines replacement and extension projects throughout the company's operating area also have been set back.

Largest of the two transmission lines referred to by Hulcy is the 70 miles of 20-in. diam pipe to extend from Garvin County in Oklahoma to Lone Star's compressor station at Petrolia in Clay County, Texas. Application for this construction has been approved by the Federal Power Commission.

Gathering lines totaling 30 miles of 18, 16, 12, and 10-in. pipe were scheduled for installation in the Golden Trend area to deliver gas to the 70-mile transmission line. These, with 15 miles of smaller diameter gathering lines, are also in the delayed status.

A 30-mile line of 12-in. diam had been scheduled for installation from the Miers gas field in Sutton County, connecting to Lone Star's transmission network near Eldorado in Schleicher County. This line was to have established a new source of supply from a new major dry gas field, Hulcy said, pointing out that construction of this pipe line has also been postponed to an extent dependent upon when the necessary pipe can be made available. Construction was to have begun the middle of July and completion was set for September 1.

The gas company owns and operates distribution plants for more than 600,000 customers in 386 cities and towns in Texas and Oklahoma. Its transmission pipe line network feeding these points exceeds 6300 miles.

September Hearing Set On Gas Commitment

Denying in part the application of Northern Natural Gas Company for modification and rehearing of the Commission's Opinion No. 230 and its order issued June 24, 1952, the Federal Power Commission set a public hearing beginning September 10, on the application for rehearing so far as it relates to certain paragraphs requiring the company to commit its natural gas reserves to rendering the services then authorized.

The commission directs that this order shall not be construed to limit the right of Northern to accept the certificate issued by order of June 24, as therein conditioned.

In its order of June 24 the commission issued to Northern Natural a certificate of public convenience and necessity subject to Northern's acceptance, authorizing the construction and operation of additional gas pipe line facilities designed to increase its delivery capacity north of Kansas from approximately 600,000,000 cu ft to 825,000,000 cu ft a day, but conditioned the order to require that Northern Natural Gas Company devote to rendering such service all the natural gas reserves its owns or controls.

Hearing on Operation Of Iowa Facilities

The Federal Power Commission has scheduled a hearing to begin September 9 in Washington, D. C., on an application by Iowa-Illinois Gas and Electric Company filed in connection with the continued operation of natural gas transmission facilities in Iowa.

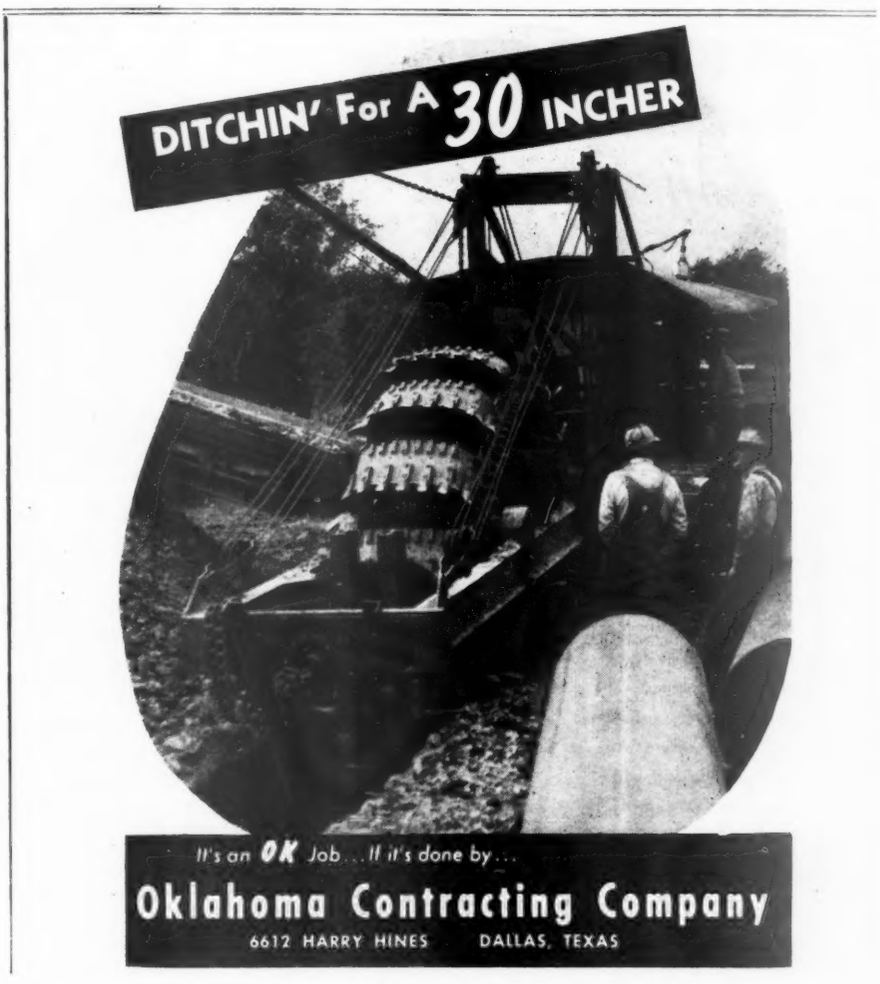
The application ask the FPC for (1) an order disclaiming jurisdiction over the facilities, or (2) authorization for their continued operation. The facilities include 23 miles of 4-in. duplicate transmission line serving Ottumka district, and 17 miles of 10-in. duplicate line serving Davenport district, in Iowa.

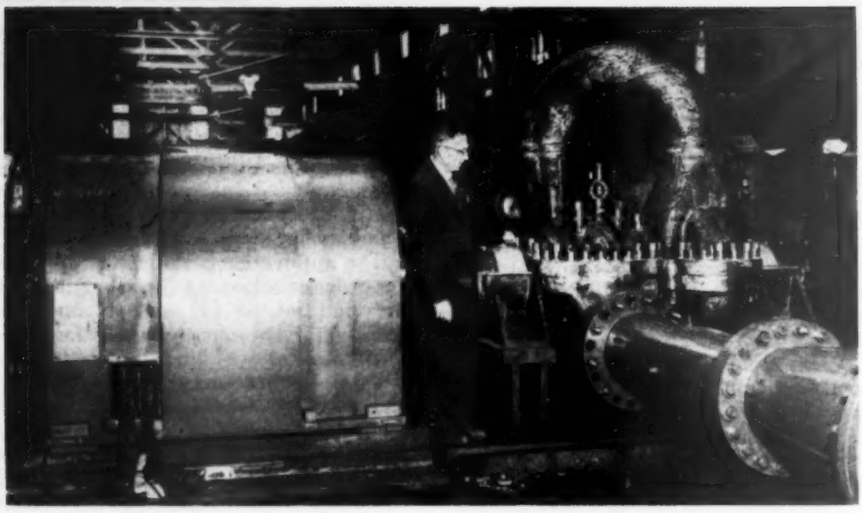
The commission denied the company's request that its application be heard under the shortened procedure for non-contested proceedings.

Standard Opens Division Office at Des Moines

Standard Oil Company (Indiana) has opened a division office for its products pipe line department at Des Moines, Iowa, according to Sam L. Jackson, department manager at Chicago.

R. H. Starrett is in charge of the new Des Moines office. He is division superintendent in charge of the products pipe line from Standard's Sugar Creek, Missouri, refinery to Council Bluffs, Sioux City, and Des Moines, Iowa, and Sioux Falls, South Dakota.





H. A. Johns, chief engineer, Gulf's pipe line division, standing before United's 16-in. BFD-E two-stage pump.

Pumps Tested for New Crude Oil Pipe Line

H. A. Johns, chief engineer of the Gulf Oil Company, Pipe Line Division, is shown standing in front of one of the twelve 16-in. BFD-E 2-stage pumps undergoing its official performance test at the plant of United Centrifugal Pumps in Oakland, California. The pumps will be installed on the West Texas 24-in. crude oil pipe line that will bring West Texas oil to the gulf coast.

The pipe line is designed for an ultimate capacity of 472,000 bbl a day at 750 psi pressure.

Three 16-in. BFD-E 2-stage full head pumps and one 16-in. DVS-E single stage pump will be installed in series in each station to meet the required pressures. In addition to the mainline booster pumps twenty-nine 20-in. "in-line" pumps will be installed in the tank farms on the same pipe line. Ultimate capacity will be 415,000 bbl a day.

New Stock Issue to Finance Expansion Projects

Dillon, Read and Company, Inc., heads an investment banking group that is offering publicly a new issue of 190,000 shares of 5.50 per cent First Preferred Stock, $100 par, of Texas Eastern Transmission Corporation. The stock is priced at $100 per share, plus accrued dividends. The new First Preferred series ranks ahead of the presently outstanding convertible preferred stocks.

Texas Eastern will use the proceeds from the new preferred stock, together with proceeds from the private sale of $30,000,000 of bonds to institutional investors, to complete financing of the company's several expansion projects, which include: (1) Construction of a new 30-in. pipe line from Kosciusko, Mississippi, to Connellsville, Pennsylvania; (2) development of large underground gas storage facilities in western Pennsylvania; and (3) a program to increase its supplies of gas in the Texas Gulf Coast area. The Mississippi-Pennsylvania pipe line was placed in service August 1, 1952. Additional investment by the parent company in Texas Eastern Production Corporation, a wholly owned subsidiary, is also contemplated.

Texas Eastern owns and operates a pipe line system extending from the Texas Gulf Coast area to New York for the transmission and sale at wholesale of natural gas, supplying customers in nine states in the area it covers.

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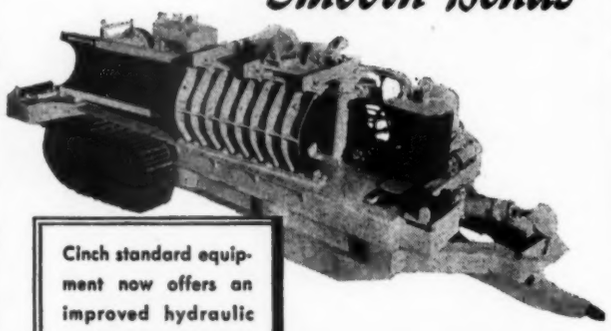

Cinch standard equipment now offers an improved hydraulic system and new wedge-type pin-up slide for greater durability and speed. If desired, even faster, easier maneuvering can be obtained with Athey tracks and hydraulic lift tongue.

Contractors swear by Cinch "Smooth Bend" Pipe Benders for dependability and uninterrupted service. Cinch Pipeline Equipment provides the most up-to-date equipment and expert maintenance.

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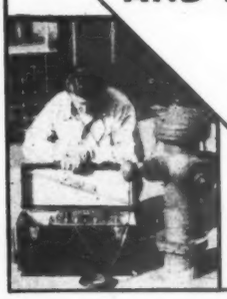

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A. I. Zumwalt

A. I. Zumwalt Promoted by Service Pipe Line Shops

A. I. Zumwalt has been promoted to superintendent of Service Pipe Line Company's Tulsa machine shops, C. M. Scott, general manager, has announced. He succeeds H. E. Heath who retired July 22 under the company's annuity plan.

Described as "fix it headquarters" for Service's 11-state, 12,000-mile pipe line system, the Tulsa shops employ 50 skilled craftsmen.

Five buildings at 1136 North Lewis Avenue house the modern machine tool, welding, and blacksmith equipment. Repair work, and fabrications, made in the shops are shipped to all points of the company's system. Pump and engine repairs are made in the shops, including the manufacture, if necessary, of all their parts. All types of pipe fabrications are cut and welded, and new devices for field installation are designed and produced.

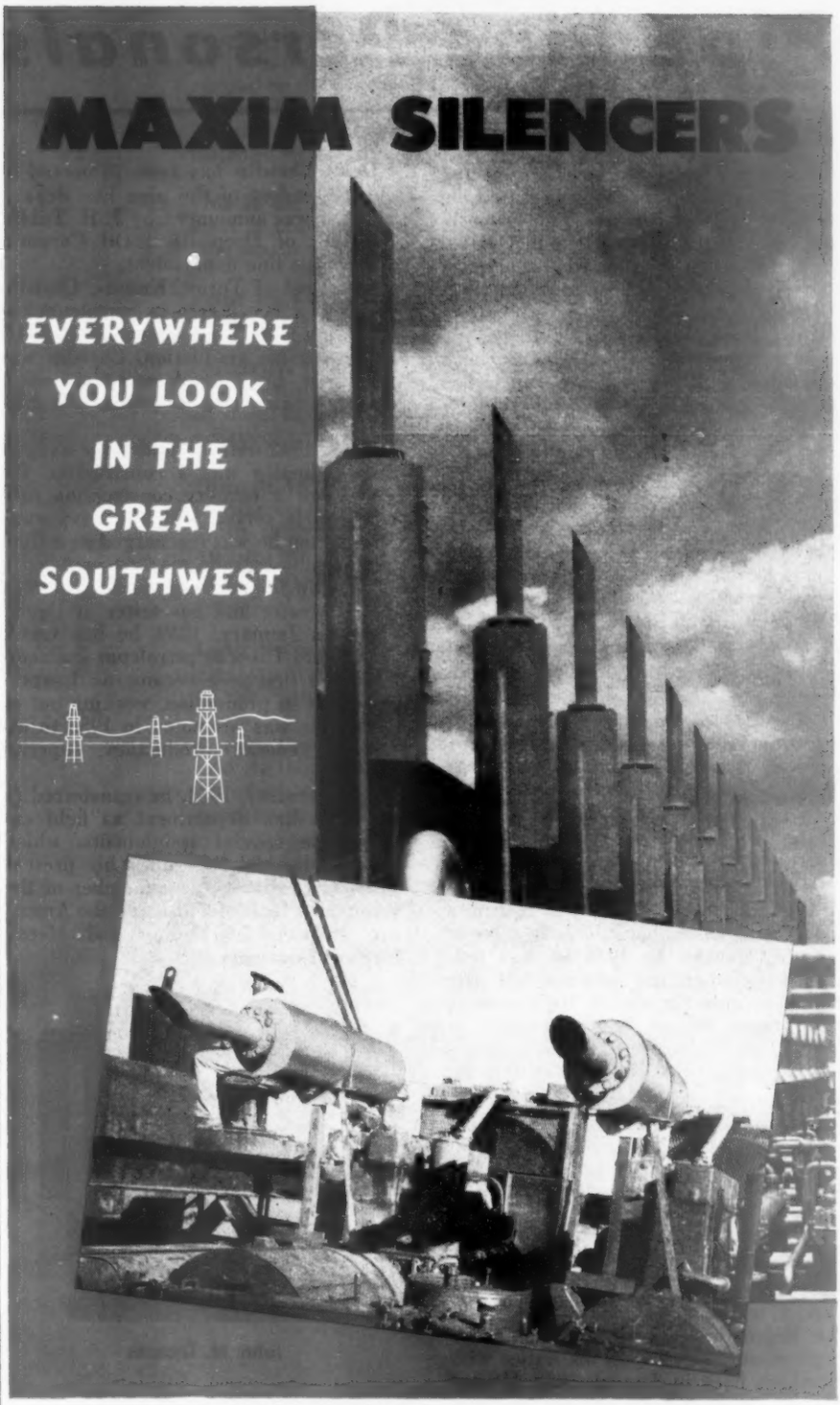
During the war Service Pipe Line Company shops assisted in fabricating several large piping jobs for War Emergency Pipe Lines. Junctions, manifolds, and scraper traps were made and shipped to Linden, New Jersey. They were installed in the New York harbor area.

A veteran machinist, Zumwalt has worked in the Tulsa shops since 1941, and was assistant machine shop foreman before his promotion.

Britton Brothers Form Contracting Firm

Britton Brothers Contracting Company, 812-13 Dan Waggoner Building, Fort Worth, Texas, has been formed to do pipe line construction work. The company is a partnership between J. C. Britton and Herbert Britton. Both men have been associated with pipe line construction for many years, J. C. since 1925 and Herbert since 1926.

In 1946 the Britton Contracting Company, a corporation, was organized. The two Brittons and Roy Clark were the owners. Herbert sold out his interests several years ago but has been associated with the company until the present time. J. C. Britton has now sold his interest in Britton Contracting Company to Roy Clark, who will continue to operate under that name for the present at least. Headquarters are in Washington, Pennsylvania.



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Pipe Line Personals

George L. Robinson has been elected vice president of the Buckeye Pipe Line Company. Robinson, who was formerly manager of the Eastern Products Division, will continue to have his headquarters at Buckeye's office at Allentown, Pennsylvania, and will be in direct charge of its new Eastern Products Pipe Line System. He has been with Buckeye since 1932 and before being transferred to Allentown, was general superintendent of the company's lines throughout Indiana, Illinois, Michigan, and Ohio.

W. H. Stueve, consulting engineer of Oklahoma City, Oklahoma, will make his headquarters in Houston, Texas, for some time, having been made electric power consultant for C-R-C Engineering Company, acting for the U. S. Pipe Line Company and the West Coast Pipeline Company, both of which will be electrified.

Eutah York has been made superintendent of Northern Natural Gas Company's Holcomb compressor station, formerly having been superintendent of the Ogden station. **Bill Werner** has been moved from Paullina to Ogden, and **Bill Alix** goes from Holcomb to Paullina.

York began working for Northern Natural in December, 1932, as oiler at Clifton, Kansas. In 1934 he was promoted to operating engineer at the Ogden compressor station. He was made compressor station superintendent at Hooper in 1941 and later was transferred to Ogden, Iowa, as superintendent.

Werner in 1931 began working for Northern at Mullinville, Kansas, as an oiler and in 1935 was made engineer at Mullinville. He was promoted to maintenance mechanic at Sublette, Kansas, in 1945 and in 1947 was made welder mechanic. The same year he was named compressor station superintendent at Paullina, Iowa.

Alix, who has been superintendent at the Holcomb compressor station since September, 1950, began his duties with Northern back in August, 1933. He has worked as an oiler, engineer, maintenance mechanic, and assistant compressor station superintendent. In 1949 he was advanced to the position of assistant superintendent at Sublette and held this position until 1950 when he was advanced to superintendent at Holcomb.

Frank N. Speller, national authority on the subject of corrosion, has become an associate member of Management Counselors, Inc., business consultants, 37 Wall Street, New York.

Dr. Speller has been actively engaged with this industrial problem for more than 25 years both in practical field operations and research. His book "Corrosion—Causes and Prevention" is now in its third international edition.

Dean Chrislip has been promoted to superintendent of the pipe line department, it was announced by J. H. Tubbs, manager of Deep Rock Oil Corporation's pipe line department.

A native of Turon, Kansas, Chrislip received a BS degree in petroleum engineering from Tulsa University in 1941. Following his graduation, Chrislip was employed by an oil company as a student engineer in its production division.

From 1942 until he joined the navy in 1944, Chrislip was a construction engineer for a refinery construction contractor. He served with the navy until 1946, when he was discharged as a lieutenant junior grade.

Chrislip joined Deep Rock in 1946 as an oil treater and gas tester at Drumright. In January, 1949, he was transferred into Tulsa as petroleum engineer, and later that year became field superintendent in production, working out of Tulsa. He was promoted in 1950 to assistant general production superintendent.

In November, 1951, he transferred to the pipe line department as field engineer on special assignments, which position he has held until his present promotion. Chrislip is a member of the Engineer's Club of Tulsa and the American Institute of Mining and Metallurgical Engineers.

John M. Thomas

John M. Thomas has been appointed vice president in charge of H. C. Price Company's pipe line division, Harold C. Price, president of the Bartlesville, Oklahoma, company has announced. Thomas, who has been serving as manager of the pipe line division, joined the Price organization in 1937. His pipelining activities include a tour of duty in the Yukon during 1942 and 1943 where he held the position of office manager for Price crews working on the Canol project.

A native of Copan, Thomas is married and has two children, Johnny, six years old, and David, three.

Donald F. Sears has been named vice president of Shell Pipe Line Corporation, T. E. Swigart, president, announced.

Donald F. Sears

Sears, who previously held the title of assistant to the president, joined the company as an engineer in 1927 in St. Louis, Missouri. He became a member of the board of directors in 1939.

A graduate of Worcester Polytechnic Institute with a BS degree in civil engineering, his early work with Shell was connected with its pipe line expansion program and included the design and material estimation for the company's McCamey-to-Houston 10-in. line.

In 1931 he became assistant general superintendent in charge of the company's oil gathering facilities. This assignment included design, construction, and operation and supervision of gaging practices. Three years later he was placed in charge of personnel relations and assisted in the negotiations of labor contracts. In 1939 he was made Shell Pipe Line general superintendent and assistant secretary.

Sears spent three years in Washington during World War II with the Petroleum Administration for War. He was successively chief of the pipe line section, pipe line engineering and materials section, and the pipe line operating section. He took part in the formulation of the enormous emergency construction program including the Big Inch and Little Inch pipe lines and other government and private emergency projects.

Upon his return to Shell in 1945, he was made assistant to the vice president in which his duties included heading the veterans reinstatement and employee training programs. Additionally, he supervised the purchasing and stores department and assisted in the initial development work on several pipe line projects. During this period he also acted as pipe line consultant on foreign projects by Shell companies in Venezuela, Canada, and the Middle East.

For the last two years Sears has been on special assignment in Venezuela as director of Shell Pipe Line's participation in and coordination of construction of the Palmarejo-Paraguana Peninsula Pipe Line.

Roland E. Koepp, former district superintendent for the Texas-New Mexico Pipe Line Company, Eunice, New Mexico, has opened an engineering and surveying service at 984 West San Antonio Street, New Braunfels, Texas, specializing in oil field pipe line work.

A quarter of a century ago, on September 15, 1927, six trainloads—225 cars—of pipe were consigned to the Dixie Gulf Gas Company for their line to run from Waskum to Port Arthur and Houston, Texas, comprising 300 miles of 22-inch and a small mileage of 16-inch pipe.

This is an important date because it marked the start of construction of the first large diameter pipe line made wholly of electrically welded pipe.

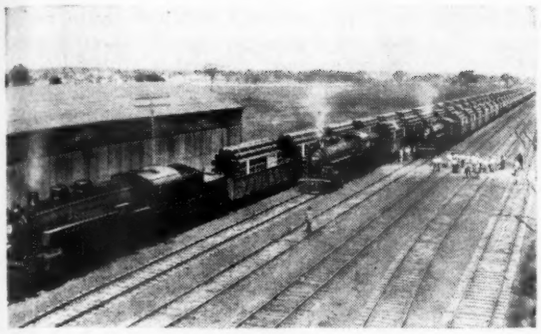
Prior to 1927 the entire large diameter line pipe manufacturing capacity of the country was less than three miles per day. With line length and capacity restricted by high cost and limited production, the few existing pipe lines of the day were necessarily of small diameter, serving only the few local markets adjacent to oil and gas fields.

Then in 1927 A. O. Smith introduced welded pipe in diameters larger than had ever been built before. With this new process, A. O. Smith could weld 40-foot lengths of pipe on a mass-production basis. Hundreds of miles of pipe could be made in a matter of weeks instead of years.

Long distance transportation of gas and oil became a practical economic reality, marking the beginning of the nation's vast pipe line system.

During these 25 years, A. O. Smith has produced and delivered a total of 31,465 miles of line pipe, all of which is in dependable operation in gas and petroleum transmission lines here and abroad.

We pledge a continuing supply in performing our part in our partnership for progress with America's pipe line companies.



First shipment—Three of the six trainloads of 22-inch welded steel line pipe ready to leave for the Dixie Gulf Gas Co. pipeline project on September 15, 1927.

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Midland 5, Texas • New Orleans 12 • New York 17 • Pittsburgh 19
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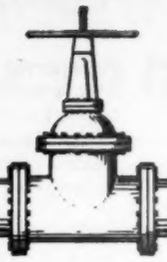
PIPE LINE PROJECTS



A 115-Mile Oil Line Approved for Canada

Canadian Gulf Pipe Line Company, wholly owned subsidiary of Canadian Gulf Oil Company, has been granted a permit by the minister of highways to construct a 115-mile pipe line from the Fenn-Big Valley-Stettler area to the Interprovincial Pipe Line Company terminal at Edmonton. Work will begin in the immediate future with completion scheduled for some time this fall. The project will cost $5,000,000.

Necessary pipe has been purchased and most of it is on hand. The capacity of the line will be approximately 35,000 bbl a day and initial pumping 10,000 to 11,000 bbl a day. Oil will be gathered from the Big Valley and Fenn fields through 4 and 6-in. lines and delivered into Stettler where a mainline pump station will be erected. Between Stettler and Edmonton the line will be of 12-in. diam.

Texas-Ohio Hearing to Reconvene in September

The Federal Power Commission hearing on proposals by Texas-Ohio Gas Company, of Houston, Texas, to build a Texas to West Virginia pipe line and to import natural gas from Mexico, will reconvene September 2 in Washington, D. C.

The commission directed the company to present all of its evidence in support of its applications at the September 2 hearing, and to complete its entire direct case without further continuance. The hearing has been recessed twice at the request of the company.

The hearing originally commenced last April 15, but was adjourned by the Commission on April 17, after the FPC staff counsel filed a motion to dismiss the application. The Commission on June 6 heard oral argument on the staff motion, and then ordered the hearing to reconvene July 7. The hearing continued from July 7 to July 14, when it was recessed at the request of Texas-Ohio until August 4. Near the close of the proceedings on that date, the company asked for a 30-day recess. The FPC presiding examiner who was conducting the hearing recessed it subject to further order of the Commission. The motion for the second recess was opposed by the FPC staff counsel and by counsel for the National Coal Association and others.

In ordering the hearing to reconvene September 2, the FPC said that the company "has been afforded abundant opportunity to complete the presentation of evidence in support of its applications . . ., but has failed to do so." However, the FPC continued, "it may be appropriate and in the public interest to afford applicant a further and final opportunity to complete its case . . ."

The Commission said that after Texas-Ohio has concluded its case, other parties, including the FPC staff counsel, may conduct as much of their cross-examination as they are then prepared to undertake. The hearing will then be recessed pending further order of the Commission.

Texas Ohio proposes to construct a 1406-mile pipe line originating on the U. S.-Mexican border in Hidalgo County, Texas, and extending to a terminus near Lancaster, Ohio. The staff counsel has contended that the company has failed to submit required data showing that it has a market for the gas it would transport through the line, and has asked that the application be dismissed without prejudice.

Hearing on Gas Export Proposal Is Postponed

The Federal Power Commission hearing on the proposals of the Tennessee Gas Transmission Company of Houston, Texas, and Niagara Gas Transmission Limited of Toronto, to export natural gas from the United States to Canada, for ultimate consumption in Eastern Ontario, which was previously set for August 6, has been postponed to September 15. It will be held in Washington, D. C., in the Commission's Hearing Room, 1800 Pennsylvania Avenue.

Pipe Line Facilities in New Jersey Sought

Public Service Electric and Gas Company, of Newark, New Jersey, has filed an application with the Federal Power Commission requesting authority to construct a total of about 16.3 miles of pipe line to transport natural gas received from Texas Eastern Transmission Corporation, of Houston, Texas, to Public Service's gas works at Harrison and Jersey City, New Jersey.

The project would include 11.3 miles of 16-in. pipe line extending from a connection with Texas Eastern's system at Linden, New Jersey, to Harrison. From there, branch lines consisting of 2.04 miles of 12-in. pipe and 2.96 miles of 10-in. pipe would extend to Public Service's Harrison Gas Works at Harrison and its West End Gas Works at Jersey City.

Public Service proposes to transport the gas purchased from Texas Eastern to its production plants where it would be used in the production of mixed gas to be distributed by Public Service to its New Jersey market. Estimated cost of the project is $4,200,000.

Work Begins on New Texas Gas Transmission Line

Texas Gas Transmission Corporation construction crews began work the early part of August on the company's new 408-mile, 26-in. natural gas pipe line.

The announcement came three days after the Federal Power Commission authorized the $33,700,000 project. The pipe line is designed to carry 240,000,000 cu ft more of natural gas a day to more than 30 distributing utilities from Louisiana to Ohio.

L. E. Ingham, vice president in charge of operations and engineering for Texas Gas, said his company would make every effort to complete as much of the line as possible before winter sets in. He added, however, that the steel strike had delayed delivery of pipe and that no definite assurance of completing the project in time for this winter's heating season could be given. Texas Gas originally had planned, barring an interruption in steel deliveries, to place the project in service by November 1.

The company has had on hand for some time 76 miles of pipe and all valves and other materials needed for the construction job. Ingham reported that assurances have been received from the pipe mills that rolling of Texas Gas pipe would proceed upon reopening of the mills.

The 76 miles of pipe on hand represents approximately 20 per cent of the pipe required for the project.

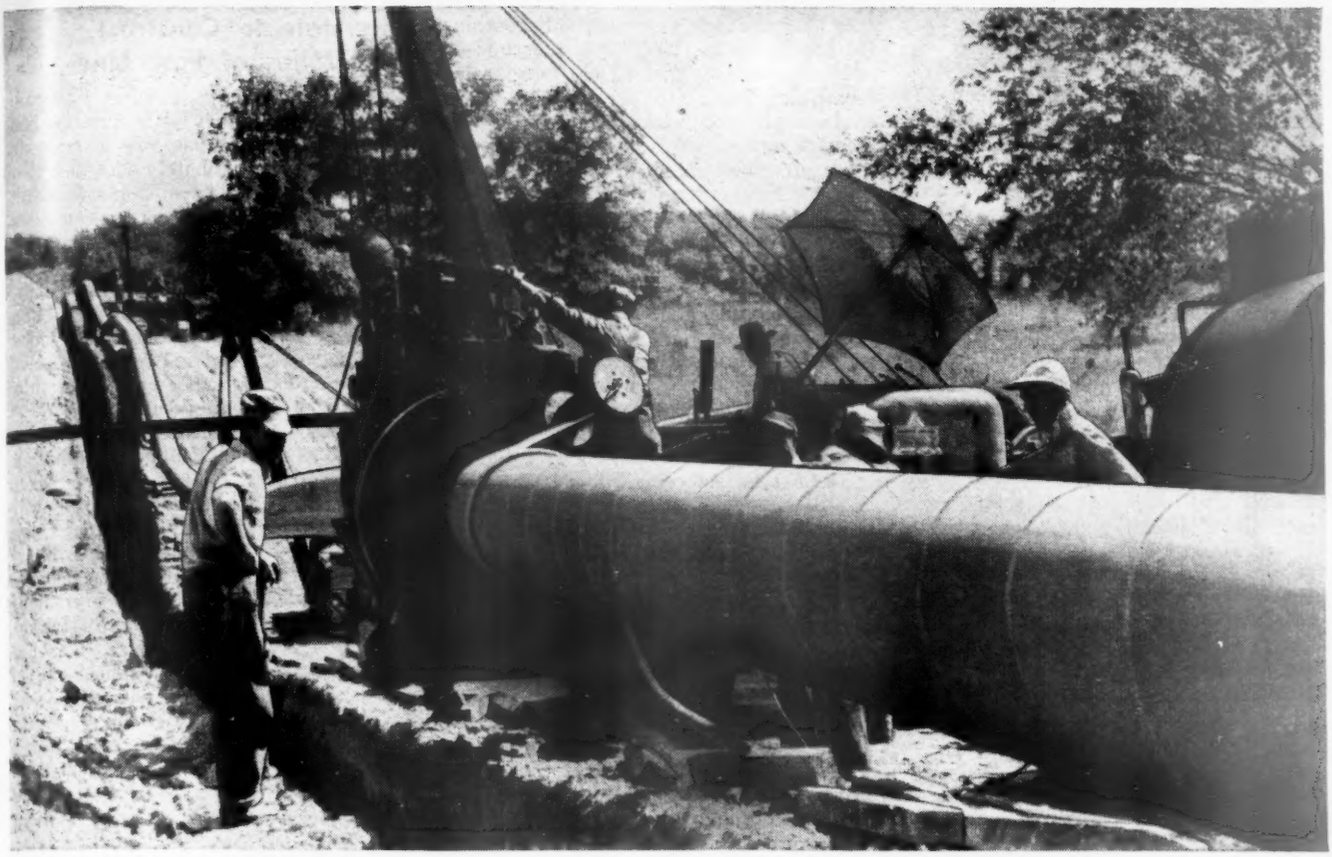
Ingham said Texas Gas has arranged with two contracting firms, H. C. Price Company of Bartlesville, Oklahoma, and Houston Contracting Company, Houston, Texas, to build the new facilities.

Prior to the FPC approval of the project, Texas Gas had completed virtually all the necessary work preliminary to construction, Ingham explained.

The 408-mile line will be built in six sections from Bastrop, Louisiana, to a point near Louisville, Kentucky. It is along the second section, a distance of 125 miles from the Mississippi River near Greenville, to Lake Cormorant, Mississippi, that construction crews will start.

Other construction sections will range from Bastrop, Louisiana, to Greenville, a distance of 46 miles; from Lake Cormorant to Kenton, Tennessee, a distance of 99 miles; from Kenton to Slaughters, Kentucky, a distance of 93 miles; from Slaughters to a point 25 miles northeast; and from Louisville, Kentucky, to a point 19 miles southwest.

The project, when completed, will raise the daily delivery capacity along an enlarged 3000-mile Texas Gas system to 950,000,000 cu ft.



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Trans Mountain Will Have Three Pump Stations

Three pumping stations, instead of the two originally planned for the initial operations of Trans Mountain Oil Pipe Line Company, are to be under construction this year, according to an announcement by Robert L. Bridges, president.

First plans called for one pumping station at Edmonton and another at Kamloops, for an initial throughput of 75,000 bbl a day.

In the light of new discoveries made in Alberta oil fields, and consequent revision of estimates of production given out by Alberta Mines Minister, N. E. Tanner, directors of Trans Mountain Oil Pipe Line Company decided to construct a third pumping station at Marlboro, about 10 miles west of Edson, Alberta.

Ultimate carrying capacity of the line will be in excess of 200,000 bbl a day, necessitating five pumping stations and a booster station.

Following an inspection trip over the line, Bridges said: "The three stations will cost in excess of $4,000,000. Bids for construction will be announced at an early date by Canadian Bechtel Limited, agents for Trans Mountain.

"Erection of the pumping station buildings is scheduled for late fall so that engine setting and other interior work can be continued through the winter.

"By having three stations available at the outset, Trans Mountain will be able to handle up to 120,000 bbl of crude a day instead of the 75,000 originally scheduled."

In connection with the board of directors meeting near Jasper, the members of the board, together with members of the construction committee, inspected the actual construction of the pipe line west of Jasper, near the Yellowhead Pass.

Construction of the pipe line began several months ago, and is scheduled for completion and in operation on or before December 31, 1953.

In making the announcement of the third pumping station, Bridges referred to a recent address of Mines Minister Tanner, in which he said: "It appears evident that Alberta will be able to supply sufficient oil to Trans Mountain for B. C., and also supply any deficiency in Pacific Coast stocks foreseeable in the near future.

"Average demand for Alberta crude during 1952 to supply the Prairie provinces and Ontario market, now served by Interprovincial pipe line, is 162,000 bbl per day.

"If Trans Mountain were ready to operate now, it is estimated that Alberta alone could still supply the Eastern market, plus 38,000 bbl daily for B. C., and still have between 40,000 and 75,000 bbl daily of light oil available for the Pacific Coast terminal of Trans Mountain."

Commenting on this, Bridges said: "Discoveries and additional development by the time the line is in operation is expected to increase the crude oil available to Trans Mountain in a figure in excess of the initial capacity of 120,000 bbl per day."

Ohio Fuel Gas Seeks Authority for Loops

The Ohio Fuel Gas Company of Columbus, Ohio, has applied to the Federal Power Commission for a certificate of public convenience and necessity to authorize construction of partial looping of existing transmission pipe lines to transport additional natural gas.

Setting forth that increased facilities will be required early in 1953 to augment existing facilities that, during summer months, transport gas available in southern Ohio to underground storage and market areas in the northern part of the state to increase capacity for winter and peak day service, the company seeks authorization for the construction of 34.5 miles of 20-in. transmission pipe line in Fairfield, Franklin, Delaware, and Licking counties, Ohio, extending from a connection with facilities of Texas Eastern Transmission Corporation to the vicinity of Johnstown, Ohio, representing a partial looping of lines B-100 and "B" between Crawford and Treat compressor stations, together with valves and incidental facilities necessary for practical operation.

Construction is scheduled to begin about March 15, 1953, and the facilities should be completed and in operation by June 1, 1953. Estimated cost of the proposed construction is $1,675,000.

Interstate to Construct 152 Miles of Pipe Line

Interstate Oil Pipe Line Company has announced plans for a pipe line construction project that will permit deliveries of approximately 50,000 bbl of crude oil per day from fields in northeast Texas to Baton Rouge, Louisiana.

Applications for materials for the projects involved in the program have been filed with the Petroleum Administration for Defense. Subject to PAD approval, construction is tentatively scheduled to begin in the first quarter of 1953 with completion expected in the third quarter of the same year.

Interstate will construct 14.5 miles of 18-in. line from a connection with another pipe line system on the Texas-Louisiana state line to a junction with its Shreveport-Baton Rouge trunk line system near Shreveport, and will lay 137.6 miles of 22-in. line between Shreveport and Baton Rouge, replacing sections of multiple 8-in. or dual 12-in. lines that are now in service. This line with two new pump stations, one of which is now under construction near Bunkie, Louisiana, will increase the capacity of the Shreveport-Baton Rouge trunk line from 107,000 to 133,000 bbl a day. Upon completion of the two new pump stations, the six existing stations on this line will be abandoned.

Should the need develop, provision has been made to increase the line's capacity to 160,000 bbl a day by replacing the remaining 34 miles of dual 12-in. lines with a single 22-in. line.

Hearing on Proposed Compressor Station

A Federal Power Commission hearing will begin September 4 in Washington, D. C., on a proposal by Southern Natural Gas Company, of Birmingham, Alabama, to build a 3300-hp compressor station in the Logansport gas field in Louisiana.

Southern said that the proposed station, estimated to cost $1,021,500, is required because of declining wellhead pressures of wells in the Logansport field.

Chicago-Detroit Products Line in Planning Stage

The Texas Company and Shell Oil Company will join Cities Service Oil Company in constructing a products pipe line from Chicago to Detroit, according to a usually reliable source. It is understood rights-of-way for the pipe line are being acquired. Details are to be announced at a later date.

First announcement of a planned pipe line eastward from Chicago was made July 16 by S. B. Irelan, Cities Service president, when he detailed an expansion program planned by that company, including $12,000,000 to be spent on the East Chicago refinery alone to increase its capacity from 35,000 to 50,000 bbl a day. Irelan said Cities Service was negotiating with two other large oil companies on a pipe line project eastward and that a line from Chicago westward also was under discussion.

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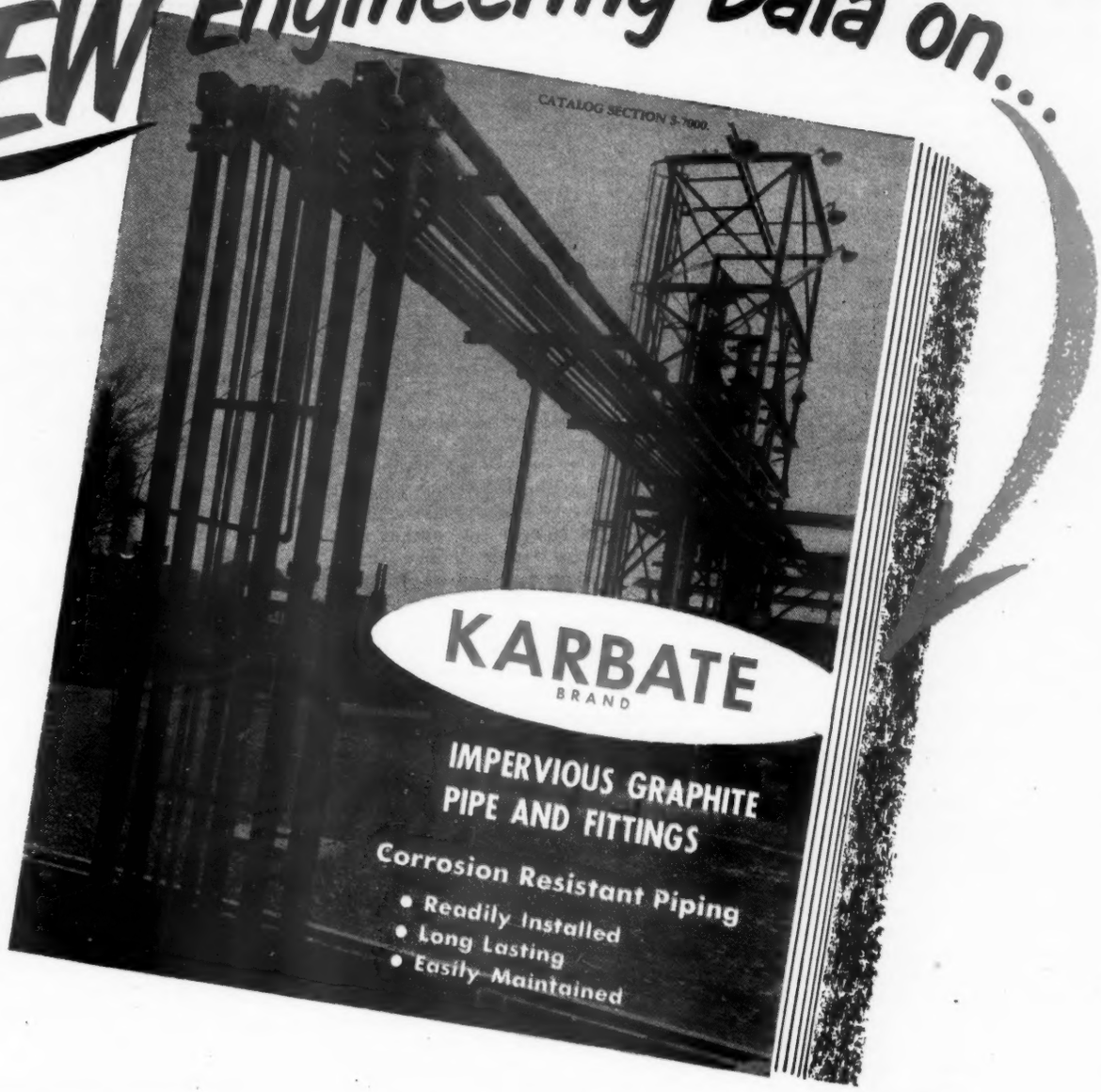

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Pipe Line Projects

Permit for Storage Facilities Asked

Lone Star Gas Company, of Dallas, Texas, has applied to the Federal Power Commission for authority to construct a 2640-hp compressor station and about 5 miles of 12-in. pipe line to store interstate natural gas in the New York City field reservoir in Clay County, Texas.

The company said that project, estimated to cost approximately $762,687 would enable it to more efficiently serve its present markets in North Texas, including the Dallas and Fort Worth area. The storage reservoir would permit the storage of gas during off-peak periods for withdrawal during peak periods.

Allowing for the necessary cushion gas to maintain required pressures in the reservoir, the company said, the effective volume of the reservoir as a gas storage project is estimated at 4 billion cu ft. The proposed compressor station would permit the injection of about 20 million cu ft per day for approximately 200 days per year, and the withdrawal of about 60 million cu ft a day.

The application says that leasing rights for the New York City field are owned entirely by Lone Star's subsidiary, Lone Star Producing Company, and that the two companies have entered into a contract whereby Lone Star Gas has acquired the right to store and withdraw gas from the field.

FPC Order Complied With by Northern Natural

Northern Natural Gas Company, of Omaha, Nebraska, has filed an application with the Federal Power Commission in connection with the construction of additional natural gas pipe line facilities in the Southwest and Midwest as a part of the large expansion program authorized by the FPC on June 24.

Northern filed the application in compliance with a condition on the June 24 authorization, which required the company to submit applications for the construction and operation of certain additional facilities that the company contended did not require FPC authorization, and (2) requesting appropriate authorization or establishing that a certificate is not required for others.

Total estimated cost of the facilities covered by the new application is $11,692,547. The construction includes about 102 miles of pipe line; approximately 14,520 additional compressor hp, and town border and main line sales measuring stations.

The FPC on June 24 authorized Northern to build facilities to increase its system capacity from 600,000,000 cu ft a day to 825,000,000 cu ft. The facilities, to be in Texas, Oklahoma, Iowa, Kansas, Nebraska, and Minnesota, include a total of 213 miles of pipe line additions and an additional 100,160 hp in compressor capacity. Estimated cost is $38,690,000.

In addition, Northern proposed to build certain other facilities that it contended did not require FPC authorization. The FPC, however, found that Northern had erroneously classified part of these facilities, estimated to cost about $7,250,000, as "gathering facilities," and conditioned the June 24 authorization to require the company to file an application for their construction. Northern contended that another portion of these facilities, estimated to cost about $3,750,000, were exempt because they did not affect system capacity. In this instance, the FPC found that the facilities apparently will require a certificate, and directed Northern to file an application requesting appropriate authorization, or establishing that a certificate is not required.

Station Planned for Carthage Field, Texas

The Federal Power Commission has scheduled a hearing to begin September 2 in Washington, D. C., on an application by Tennessee Gas Transmission Company, of Houston, Texas, for authority to construct and operate a 2640-hp natural gas compressor station in the Carthage field, Panola County, Texas.

The proposed compressor station, which initially would contain two 1320-hp units, is estimated to cost approximately $880,000. The gas that the proposed station will compress is purchased from the Chicago Corporation in the Carthage field. This gas is then transported by United Gas Pipe Line Company to a connection with Tennessee's system in Louisiana. Tennessee said that the natural pressure of some of Chicago's wells has diminished to the extent that gas can no longer be delivered at the pressure required by United without compression.

FPC Amends Rules On Application Filing

The Federal Power Commission has issued its Order No. 163 amending Part 157 of its rules and regulations relating to the form and filing of applications for certificates of public convenience and necessity.

The FPC's original notice of the proposed revision was issued March 6, 1951, and a supplemental notice was issued under date of May 1, 1952. Numerous suggestions and comments subsequently were submitted by interested persons. The commission said that all these suggestions and comments have been carefully considered and, to the extent deemed pertinent and desirable, have been embodied in the amendments.

The changes generally are designed to eliminate incomplete applications, requiring extensive correspondence to supply deficiencies, by placing upon the applicant the burden of adequate presentation of certificate applications; to provide for the filing of abbreviated applications in the case of relatively minor operations, sales, service, construction, extension, or acquisitions; to provide general improvement in the form and content of applications, and generally to improve the efficiency in handling gas certificate applications.

The new rules will become effective September 15, 1952.

Pipe Line to Be Laid From Zubair to Fao, Iraq

The output of the oilfield at Zubair, Iraq, is to be increased fourfold by the laying of a 24-in. pipe line parallel to the existing 12-in. line that now carries oil at the rate of 40,000 bbl a day to the Iraqi oil port of Fao, at the head of the Persian Gulf. Under the recent 50-50 oil agreement between the Iraq Petroleum group of oil companies (in which Anglo-Iranian has a 23¾ per cent interest) and the Iraqi Government, the Basrah Petroleum Company has undertaken to produce a minimum of 160,000 bbl a day of crude oil from the Basrah concession by 1955. Two additional jetties and ancillary equipment are being installed at Fao.

With this new pipe line and the recently completed 556-mile, 30-in. pipe line from Kirkuk to Banias operating with existing pipe lines, Iraq's overall output will be 600,000 bbl a day, available at Mediterranean and Persian Gulf ports.

The new 80-mile long Zubair-Fao pipe line will consist of 17,000 tons of 24-in. pipe and cost more than £900,000 ($2,520,000). The contract for line pipe has been placed with the British firm, South Durham Steel and Iron Company Ltd.

First consignments of pipe are already on their way to the Basrah Petroleum Company. Production of the pipe is by a new technique that rolls steel plates in lengths of 26 ft and fixes them with an inside seam welding. Reinforced bead welding on the outside completes the process and the welds are put periodically to X-ray tests. Other tests include "bouncing" a 400-ft length of pipe from 8 ft and dropping it from 15 ft to simulate the most pessimistically conceived conditions that could be met in transit.

Target date for completion and delivery of the pipe is next March.

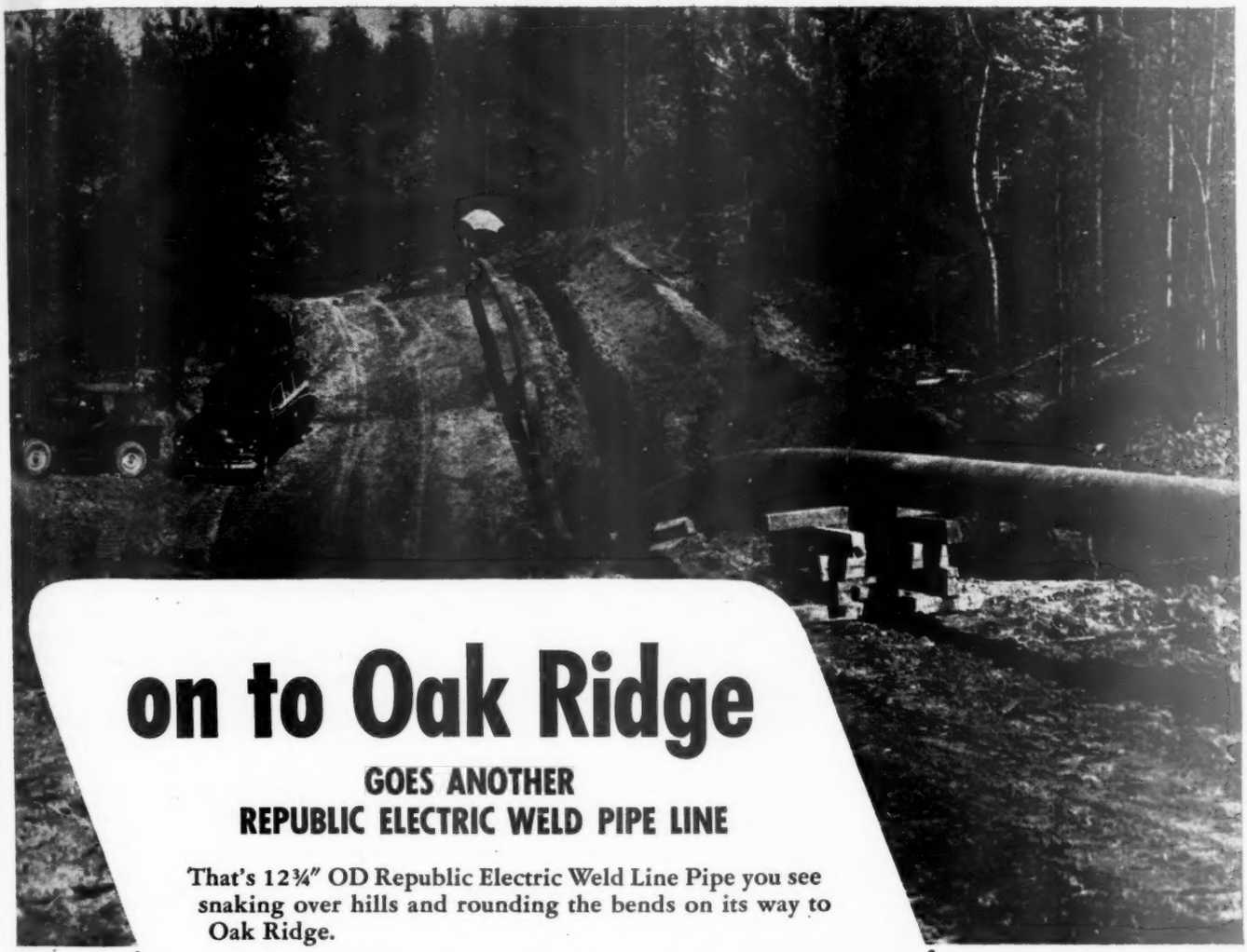
Microwave Communications In Pipe Line Industry

Multichannel microwave radio relay systems supplying private communications to cross country gas and oil pipe lines represent a capital outlay of nearly $12,000,000 to date, according to a report published in the current issue of McGraw-Hill's *Electronics*.

The two longest systems, designed for Mid-Valley Pipeline Company and Texas Illinois Natural Gas Pipeline Company, each extending approximately 1000 miles, have been in operation for some time. These systems are Motorola engineered.

According to *Electronics*, the pipe line communications and statistical experts have concluded that any user of four or more private communications channels may well turn to microwave relay systems as the economic and functional solution to their problems.

Microwave systems, compared to pole line construction, do not require continuous easements, use tons less critical copper in a 1000-mile system, and enjoy minimum susceptibility to maintenance headaches generated by wind and icing, it is pointed out.



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Bechtel Corporation, 220 Bush Street, San Francisco 4, California, has four spreads in the field laying 225 miles of pipe line in Connecticut, Massachusetts, and New Hampshire for the Northeastern Gas Transmission Company. Of this total, 100 miles will be 16-in. pipe and 125 miles 3, 4, 6, and 8-in. The job office is at 7 West Main Street, Plainville, Connecticut. S. D. Bechtel, Jr., is division manager; R. L. Bowman, general superintendent, and W. H. Molander, senior office manager.

The spread offices are as follows:

Spread 1: 7 West Main Street, Plainville, Connecticut; V. L. Williams, superintendent.

Spread 2: 52 Pulaski Street, Stamford, Connecticut; J. L. Work, superintendent.

Spread A: P. O. Box 181, Derry, New Hampshire; D. B. Alexander, superintendent.

Spread B: Winsted, Connecticut; M. A. Roberts, superintendent.

Parkhill Truck Company (Stringing Contractor), P. O. Box 1856, Tulsa, has the following jobs underway.

280 miles 14-in. line and 320 miles of 8-in. take-up for Shell Oil Company, from Wood River, Illinois, to East Chicago, Indiana.

100 miles of 16-in. and 125 miles of 3 to 8-in. scattered sections in Connecticut, Massachusetts, and New Hampshire for Northeastern Gas Company. Contractor: Bechtel Corporation. R. C. Parker superintendent.

Approximately 60 miles of 30-in. for United Gas Pipe Line Company from Sterlington, Louisiana, to Clarence, Louisiana. Contractor: River Construction. Foreman, Charles Sampson.

H. C. Price Co.—Pipeline Division, P. O. Box 1111, Bartlesville, Oklahoma, has the general contract covering construction of aproximately 363 miles of 26-in. natural gas loop lines for Texas Gas Transmission Corporation from east bank of Mississippi River near Greenville, Mississippi, to Jeffersontown Station, Kentucky, a few miles east of Louisville. Spread Four is located at Cleveland, Mississippi; Box 112, Telephone 833. C. R. Ice is superintendent; G. A. Harvey, office manager; R. J. Immel, office clerk; Fred W. Simmons, timechecker; L. R. Clark, materialman; Paul E. Hawkins, engineer; C. E. Birmingham, chief mechanic; Jesse Cash, brush foreman; E. W. Whisenant, ditch; W. O. Elliott, dozers; Forest Loinette, bending; W. T. Dickerson, pipe; L. O. Reutzel, welding; N. D. Adams, coating; J. C. Rich, lower-in, and J. E. Hamilton, cleanup.

Movement of Spread Two to this project contemplated at an early date.

A general contract with Tennessee Gas Transmission Company covers construction of 83 miles of 26-in. natural gas pipe line in two loops, one of 23.4 miles near Carrollton, Ohio, and the second 59.52 miles in length near Athens, Ohio. Spread One has its field office at Wellston, Ohio; Box 1755; Telephones 547 and 549. G. A. Reutzel is superintendent; W. E. Yount, office manager; Ernest Dickson, office clerk; R. D. Anderson, materialman; Kenneth George, engineer; J. H. Ingram, chief mechanic; K. N. Adkins, road crossing foreman; J. A. Hairston, brush; Lloyd J. Loncarich, ditch; J. C. Anderson, bending; H. C. Morrison, pipe; R. W. Orr, welding; S. J. Wood, coating; Athel Bell, lower-in; T. E. Walker, cleanup, and Charles Schooler, warehouseman.

H. C. Price Co.—Somastic Division, Box 1111, Bartlesville, Oklahoma, has the following jobs in progress at its Bustleton, Pennsylvania, plant:

Philadelphia Gas Works Company—Application of Somastic coating to approximately 114,036 ft of pipe ranging in size from 1 to 30 in.

Okonite-Callender Cable Company—Application of Somastic coating to 11,005 ft of 6-in. pipe.

Philadelphia Electric Company—Application of Somastic coating to approximately 141,329 ft of pipe ranging in size from 4 to 8⅝ in. Application of Hevicote to an undetermined quantity of 6⅝ and 8⅝-in. pipe.

South Jersey Gas Company—Application of Somastic coating to approximately 53,943 ft of 6⅝ and 8⅝-in. pipe.

Gulf Oil Corporation—Application of Somastic coating to approximately 53,360 ft of pipe ranging in size from 6 to 24 in. Application of Hevicote to approximately 9300 ft of pipe ranging in size from 8⅝ to 16 in.

C. J. McGonigal — Application of Somastic coating to approximately 2322 ft of pipe ranging in size from 3 to 12 in.

Brown Lite Company, 135 North Sheridan Road, Tulsa, Oklahoma, has been at work since the early part of August on 43 miles of 10-in. for the Arkansas-Missouri Power Company, near Kennett, Missouri. T. H. Edmonds is spreadman and H. E. Lipke office manager.

The contractor also began work in August on 185 miles of 6-in. take-up between Stoy, Illinois, and Hagerstown, Indiana, for Commercial Metals Company of Dallas, Texas. The field office is at Sullivan, Indiana. A. C. Holder is spreadman and Carl L. Huffaker office manager.

Morrison Constructors, Odessa, Texas, is laying approximately 25 miles of various size pipe in South Texas for Tennessee Gas Transmission Company. The field office is at Raymondville, with Emmitt Wilkerson spreadman and L. W. Clare office manager.

Tulsa-Williams Company, National Bank of Tulsa Building, Tulsa, Oklahoma, has under construction 143 miles of 10, 24, and 26-in. pipe line for Algonquin Gas Transmission Company in New York, New Jersey, and Connecticut. The central office for the project is at Danbury, Connecticut. R. L. Buck is general superintendent, R. E. Higgenbotham office manager, and George Littlejohn project engineer.

One spread is working from Denville, New Jersey, where O. R. Mitchell is superintendent and Paul Mackie office manager.

A second spread has its field office at Suffern, New York. "Whitey" Martin is superintendent and Sam Davis office manager.

A third spread is working out of Waterbury, Connecticut. T. E. Davis is superintendent and Walt Smeltz office manager.

O. R. Burden Construction Corporation, 6702 East 21st Street, Tulsa, Oklahoma, is working on 175 miles of 22-in. between Salisbury, Missouri, and Forest City, Illinois, for Sinclair Pipe Line Company. Two spreads are in the field. At Shelbina, Missouri, Bruce Williams is in charge as superintendent and Walt Hill is office manager. The second spread is making its headquarters at Camp Point, Illinois. Floyd Lewis is superintendent and Howard Smith office manager.

Approximately 425 miles of 8 and 12-in. pipe is being taken up and reconditioned for Sinclair between Salisbury, Missouri, and Wood River, Illinois. Two spreads are on this job also. Paul E. Thibodeaux is superintendent at Mexico, Missouri, Guy Carder office manager, and H. Y. Stephens master mechanic. At St. Peters, Missouri, "Whitey" Gould is in charge, E. A. Bell office manager, and John Owens master mechanic.

Work has stopped on the Platte Pipe Line job as there is no pipe but is expected to resume the early part of September. Pipe is scheduled to leave the mills September 2 and reach the job September 7. The section being laid by this contractor is 120 miles of 20-in. from Salisbury to St. Joseph, Missouri. The field office is at Cameron with Al Perry superintendent and Bill Clyma office manager.

Associated Pipe Line Contractors, Inc., 3272 Westheimer Road, Houston, Texas, has contracted 200 miles of 3-in. through 16-in. for Algonquin Gas Transmission Company in Massachusetts, Connecticut, and Rhode Island. Two spreads are working. L. H. Gray is spreadman for the crew having its headquarters at Tauton, Massachusetts, with Jack Bradley office manager. The second spread is at North Haven, Connecticut, with Cecil Rogers in charge.

Comstock Midwestern, Ltd., 206 Laird Drive N. Leaside, Ontario, Canada, has been at work since late in May on 472 miles of 24-in. pipe line for Trans-Mountain Oil Pipe Line Company, which will extend from Edmonton, Alberta, to Vancouver, British Columbia. The central project office is at 3390 Kingsway, Vancouver. The telephone number is Dexter 5511. C. C. Bledsoe is project manager, Charles Rathgeb, Jr., assistant project manager, M. T. "Bill" Wilhite general superintendent, A. T. Tolbert assistant superintendent, and Mike Seville office manager.

The two spreads are located as follows:

Jasper, Alberta: John Work spreadman, D. E. Anderson office manager, and Herb Allen master mechanic.

Red Pass Junction, British Columbia: "Mope" Work spreadman, N. O. Boies office manager, and Ralph Burnett master mechanic.

From the field office at Woodstock, Ontario, 171 miles of 6, 10, and 12-in. pipe line is being laid for the Sarnia Products Pipeline Company between London and Toronto. Denver L. Franklin is superintendent, Alma M. King office manager, C. M. Michael master mechanic, and Jasper Peck chief inspector.

Sparling-Davis Company, Ltd., 7310 99th Street, Edmonton, Alberta, Canada, is laying 185 miles of 10-in. line for Trans-Northern Pipe Line Company from Kingston to Hamilton. The field office is at Brighton, Ontario. Key personnel are as follows: Ray Abney, spreadman; C. R. Beighle, office manager; Tom McLeod, right-of-way foreman; "Shorty" Erard, ditch; D. Matthews, pipe; B. Doyle, lowering-in; Jim Kerr, clean-up; "Pinky" Bolin, welding; "Red" Stokes, bending, and Johnny Gregory, master mechanic.

The contractor also is installing a crossing of the South Saskatchewan River in the Province of Saskatchewan for the Interprovincial Pipe Line Company. C. S. Wiltshire is superintendent and Vernon Longston foreman.

Jim J. McCormick Company, Box 2014, Wichita Falls, Texas, has contracted to take up for Magnolia Pipe Line Company 33 miles of 8-in. and 10 miles of 6-in. between Purcell and Shawnee, Oklahoma, and to lay 25 miles of 8-in. between Addington, Healdton, and Fox Field, Oklahoma. The field office is at Purcell. T. C. Pierce is superintendent and L. W. Killough, Jr., office manager.

Anderson International Contractors, Ltd., Room 30, Miller Building, Edmonton, Alberta, Canada, has contracted to lay 67 miles of 12-in. pipe for Canadian Gulf Pipe Line Company. Right-of-way is being cleared but pipe will not start until a later date. Dick Jernigan will be the spreadman. At present Jernigan is in charge of work on the Interprovincial Pipe Line Company system, consisting of 100 miles of 16-in. between Somerset and Carroll, Manitoba. Bill Aldridge is office manager on this spread.

Oklahoma Pipe Line Constructors, 6612 Hines Boulevard, Dallas, Texas, has completed the 70 miles of 30-in. for United Gas Pipe Line Company, laid from Houston, Texas, to the south bank of the Trinity River.

Two spreads are in operation on the 116 miles of 30-in. for Tennessee Gas Transmission Company, which is being laid in three loops between Refugio and Cleveland, Texas. One field office is at Rosenberg, where Ed Flannagan is superintendent and Henry Scherrer office manager. The other spread is working out of Cleveland. Raymond Law is superintendent and Henry Turner office manager.

The Rancho Pipe Line System project, a joint venture with Houston Contracting Company, has 18 miles to go and has been shut down for some time; however, it is expected that pipe will be received about September 1 to enable this work to proceed. The job involved 68 miles of 24-in. from the Shell refinery at Pasadena, Texas, west to the Brazos River.

Anderson Brothers Corporation, 6300 Navigation Boulevard, Houston, Texas, began work late in July on 80 miles of 24-in. for Mesa Pipe Line Company (Gulf) between Colorado City and Midland, Texas. The field office is at Big Spring.

Bob McGee is superintendent, Dick Bond office manager, and Tom Marks master mechanic.

Two spreads are in operation on the 107 miles of 30-in. for Tennessee Gas Transmission Company in Mississippi and Tennessee. The spread under "Rusty" Killingsworth has its field office at Bolivar, Tennessee. Russell McDowell is office manager and C. L. Fleming master mechanic. The second spread is at Holly Springs, Mississippi. A. B. Haynes is superintendent, Jack Slack office manager, and "Red" Williams master mechanic.

Work on the Rancho Pipe Line System has been shut down because of pipe shortage but is expected to get underway again about the middle of September. The 267 miles of 24-in. are being laid from McCamey, Texas, to Cedar Valley.

The field office is at Menard, with Aldress Kilgore superintendent, Hamp Hill assistant, and Karl Smith office manager.

Canadian-Parkhill Pipe Stringing, Ltd., Toronto, Canada, is stringing approximately 200 miles 6, 10, and 12-in. for Imperial Oil, Ltd., from Sarnia to Toronto, Canada. Contractor, Comstock-Midwestern, Ltd. Superintendent, Curtis Williams.

469 miles of 24-in. for Trans Mountain Oil Pipe Line from Acheson, Alberta, to Burnaby, British Colombia. Contractors: Comstock-Midwestern, Ltd., and Canadian Bechtel. Superintendent, Jack Williams.

360 miles of 10-in. for Trans-Northern Pipe Line Company from Hamilton, Ontario, to Montreal, Quebec, Canada. Contractors: Sparling and Davis Company, Ltd., and Williams Brothers.

Trojan Construction Company, 1416½ North Robinson, Oklahoma City, Oklahoma, is taking up and reconditioning in part 376 miles of 10 and 12-in. pipe in Indiana and Ohio for the Ohio Oil Company. The job was subcontracted from Conyes Construction Corporation. Charles T. "Swede" Tillotson is general superintendent. Two spreads are being employed. One spread is working out of Roachville, Indiana, at the present time. Maurice Crawford is spreadman and Don Wilson office manager. "Slim" Deavers is in charge of the crew having its headquarters at Bluffington, Indiana. R. W. Wells is office manager.

Conyes Construction Corporation, 2884 San Pablo Avenue, San Pablo, California, is laying 320 miles of 10-in. and 12-in., and 25 miles of 8-in., plus a river crossing, for the Ohio Oil Company. The work is being done in Ohio and Illinois. The project office is at Mansfield, Ohio, with Al Poggi general superintendent and Fred King office manager.

The spread under M. A. Norwood is working out of Staunton, Illinois. Dick Comstock is office manager. The second spread has its field office at Galion, Ohio, where J. L. Walker is superintendent and E. E. Haworth office manager.

The third spread, under Floyd Hudnall, is working from Wood River, Illinois. This spread has the 8-in. pipe and the river crossing.

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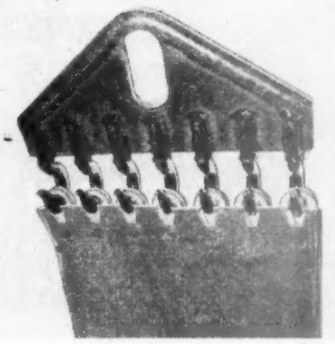

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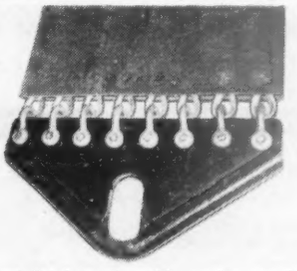

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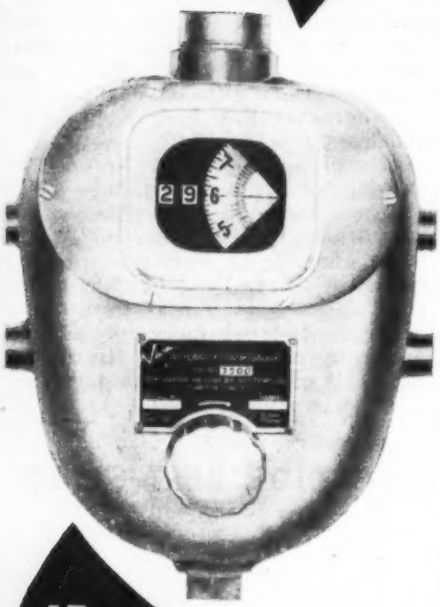

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Pipe Line Contractors

Engineering Construction Company, Tulsa, Oklahoma, has contracted to lay 50 miles of 10-in. for the Kansas-Nebraska Natural Gas Company from Ogallala to North Platte, Nebraska. The job is now waiting on government approval. The field office will be at North Platte, with Lee Vaughn general superintendent, Loyd Evans spreadman, and V. L. Bethel office manager.

Rumsey Brothers Pipe Line Construction Company, 4039 North Broadway, Wichita, Kansas, expects to resume work by mid-September on the Platte Pipe Line Company job. Pipe shortage has caused a shut down. This contractor will construct 100 miles of 20-in. between Marysville, Kansas, and St. Joseph, Missouri. The field office is at Hiawatha, Kansas, with Myrl Rumsey superintendent and Glenn Stitt office manager.

River Construction Corporation, 6100 Camp Bowie Boulevard, Fort Worth, Texas, has completed its work in Louisiana for United Gas Pipe Line Company except for crossings of the Ouachita and D'Arbonne rivers. This work continues with the spread under "Banty" Traweek working from Monroe. Paul Upton is in charge of the office.

The work in Texas was shut down for a time due to shortage of pipe but has started up again. At the time of the shut down there were 68 miles to lay. One spread has its field headquarters at Jasper, Texas, where Jimmy Reid is superintendent and Pat Rogan office manager. Another spread is at Livingston. Barney Hall is superintendent, "Borger Red" McMenamy assistant, and Lee Green office manager.

A river crossing spread, working on the Neches and Angelina rivers, has its headquarters at St. Augustine, Texas. Charley Simmons is superintendent and Ed Pratt office manager.

J. E. Young Pipe Line Contractor, Inc., 931 East Rosecrans Avenue, Los Angeles, California, has in progress the laying of 41 miles of 8⅝-in. pipe for the Southern California Edison Company between Santa Fe Springs and Etiwanda, California. Jack Cook is project superintendent and Ronny Cook spread superintendent.

Harford Brothers Pipe Line Construction Company, Emporium, Pennsylvania, has run out of pipe and been forced to close down its work for the Lake Shore Pipe Line Company. The contractor was laying 75 miles of 10-in. pipe from Cochranton, Pennsylvania, to Ashtabula, Ohio, then west to Fairport Harbor, Ohio. The field office has been at Lineville, Pennsylvania, with A. M. and W. E. Harford supervising, Earl Dell spreadman, and W. Q. Harris office manager.

E. C. Pritchett Company, Houston, Texas, is laying 34 miles of 30-in. between Drew and Stoneville, Mississippi, for Tennessee Gas Transmission Company. The field office is at Shaw, with Earl Saulsman superintendent, Frank Hindman office manager, and Pete Fraley and Dick Duncan, pipe foremen.

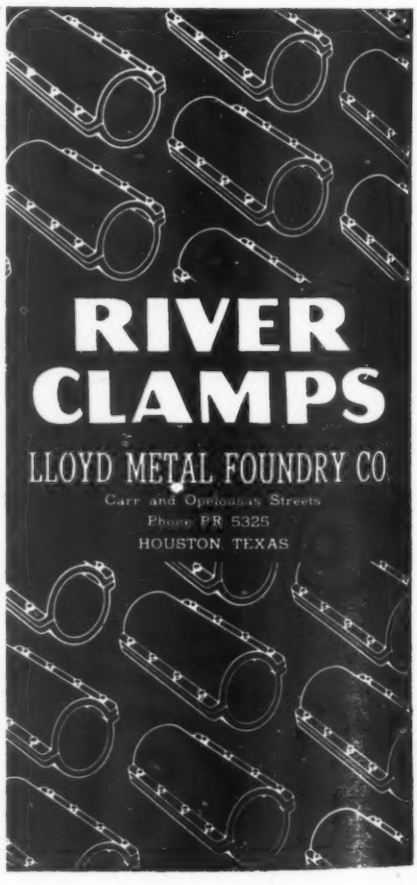
R. H. Fulton and Company, P. O. Box 1526, Lubbock, Texas, has contracted to lay 55 miles of 8-in. for Pioneer Pipe Line Company in the vicinity of Salt Lake City, Utah. Jerry Nash is spreadman.

Work is expected to be resumed about the middle of September on the Platte Pipe Line Company job, which has been shut down due to pipe shortage. Overall, the contractor is laying 433 miles of 20-in. between Casper, Wyoming, and Holdrege, Nebraska. The field office is at North Platte, Nebraska, with A. A. Carrigan spreadman.

When authorization is received from the Federal Power Commission, 100 miles of 26-in. pipe will be laid for Northern Natural Gas Company in Kansas and Nebraska. This will be in four loops.

Holder Construction Company, Snyder, Texas, is installing a gathering system in Borden and Howard counties, Texas, for the Reef Field Gasoline Corporation, consisting of about 100 miles of 3-in. through 12-in. pipe. C. O. Holder, Jr., is superintendent and L. Arnold office manager.

Vaughn and Taylor Construction Company, P. O. Box 1351, Wichita Falls, Texas, is laying a gathering system in the vicinity of Odessa, Texas, for Phillips Petroleum Company that consists of 268 miles of 2-in. through 30-in. pipe. D. D. Vaughn is superintendent and Clark Sayles office manager.



Fulghum Contracting Corporation, P. O. Box 1181, Harrisburg, Pennsylvania, is laying approximately 100 miles of 4, 6, and 10-in. pipe for Algonquin Gas Transmission Corporation. The work is being done in Massachusetts and Rhode Island and was sub-contracted from the Associated Pipe Line Contractors, Inc. The field office is at Somerset, Massachusetts, with two spreads in the field, one under Virgil Dorgan, the other under Alvyn Spears.

James H. Merritt Construction Corporation, 28 Wolcott Street, Hyde Park, Massachusetts, expects to complete the middle of September, 40 miles of 6-in. through 12-in. pipe line for Algonquin Gas Transmission Company. J. O. Blackmon is superintendent and Ken Colby office manager. The job is being handled from the main office at Hyde Park.

Anderson Brothers of Venezuela, C. A., 6300 Navigation Boulevard, Houston, Texas, is laying a crossing of the Gulf of Coro in Venezuela for Creole Petroleum Corporation, which will require approximately 80,000 ft of 26-in. pipe. The field office is at Las Piedras. "Red" Goode is superintendent.

Williams Brothers Corporation of Canada, Edmonton, Alberta, Canada, is engaged in laying 176 miles of 10-in. products pipe line between Kingston, Ontario, and Montreal, Quebec, and 46 miles of 6-in. from Farrens Point, Ontario, to Ottawa, Ontario, for Trans-Northern Pipe Line Company. The field office is at Gananoque, Ontario. "Peewee" Petty is superintendent, Claude Lightfoot assistant superintendent, and Charlie Simms office manager.

Reese Brothers Construction Company, Hugoton, Kansas, began several gathering system projects for Northern Natural Gas Company that had to be shut down until pipe can be obtained. The work is divided into areas as follows: 40 miles in the vicinity of Rolla, Kansas; 30 miles in the Garden City area, and 100 miles south and west of Guymon, Oklahoma. The work kicked-off May 23 and was shut down July 4. About 15 miles had been laid at that time. Pipe sizes are 4, 6, 8, and 12-in. Paul G. Reese is general superintendent, Gale Reese welding foreman, Edgar H. Reese spreadman, and L. S. Patterson, office manager. Patterson has replaced C. R. Beighle, who is now in Canada.

Sheehan Pipe Line Construction Company, 529 National Bank of Tulsa Building, Tulsa, Oklahoma, is installing a 12-in. river crossing on the Maumee River near Maumee, Ohio. C. M. Brown is in charge.

Midwestern Constructors, Inc., 105 North Boulder, Tulsa 3, Oklahoma, makes this construction progress report:

Aluminum Ore Company, Bauxite, Arkansas. Process piping, fabrication, 70 per cent completed; installation, 50 per cent completed. Earl S. Powell, superintendent, Morris Garey, office manager; Jack Graham, Elwood Rolfs, and Ralph Bray, area superintendents.

Natural Gas Pipeline Company of America, Chicago, Illinois. Manifold alterations at Station 107, Emerson, Iowa; 35 per cent completed. Walter D. Smith, Jr., superintendent; Dale Baird, engineer, and O. L. Westrum, office manager.

Manifold alterations at Station 108, Truro, Iowa, 35 per cent completed. Orrin J. Watrous, superintendent; Pat T. Moore, engineer, and R. E. Brewer, office manager.

Sinclair Pipe Line Company, Independence, Kansas. Construct pump station, Quincy, Illinois; 30 per cent completed. Ray M. Johnson, superintendent; Charles Malone, engineer, and W. D. Kaufman, office manager.

Install piping at Humboldt, Kansas, station; 25 per cent completed. W. E. Taylor, superintendent, and J. A. Stokes, office manager.

Construct pump station, Pontiac, Illinois; 10 per cent completed. K. L. Kreamalmyer, superintendent; Fred Trompler, engineer, and Duane C. Routh, office manager.

Dunn Bros., 801 Mercantile Securities Building, Dallas, Texas, are stringing 80 miles of 30-in. pipe in Tennessee and Kentucky for Tennessee Gas Transmission Company. Western Pipe Line Constructors, Inc., is the prime contractor.

For the Texas Eastern Transmission Corporation, an indefinite mileage of 30-in. is being strung in Ohio and West Virginia. H. C. Price Company is the prime contractor.

In Illinois, Indiana, and Ohio, 320 miles of 10 and 12-in. pipe is being strung for Ohio Oil Company. Conyes Construction Corporation is the prime contractor.

In Ohio, 60 miles of 26-in. pipe is being strung for Tennessee Gas Transmission Corporation.

Work continues for El Paso Natural Gas Company in New Mexico and Arizona.

Western Construction Company, P. O. Box 1135, Hobbs, New Mexico, has underway 105 miles of 8-in. pipe line for Continental Pipe Line Company, extending from Port Isabel to the Rincon field, Texas. The spread is working out of Harlingen under Morris Lasley.

G. G. Griffis Construction Company, P. O. Box 418, Tulsa, Oklahoma, has contracted 36 miles of 20, 24, and 26-in. from Northern Natural Gas Company, work to begin as soon as the Federal Power Commission gives authorization. The pipe will be laid in the vicinity of St. Paul and Minneapolis, with the field office at the former.

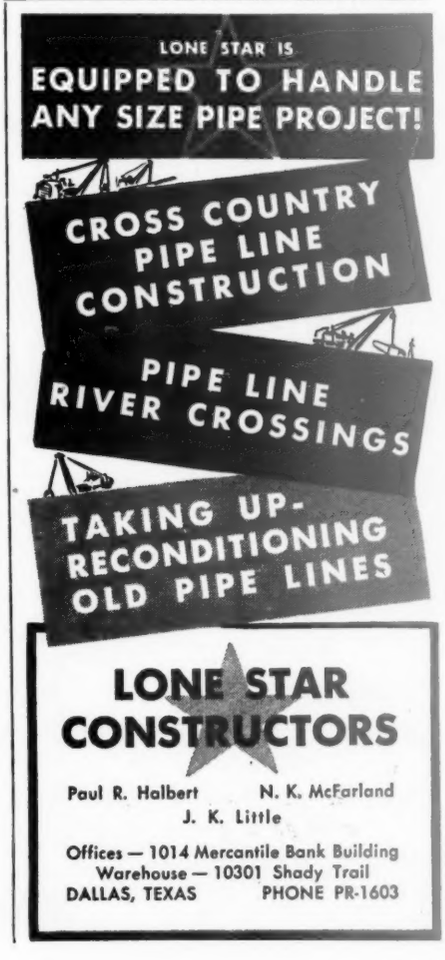
Panama-Williams Company, 403 Melrose Building, Houston, Texas, has under construction 38 miles of 20-in. pipe line for West Texas Gulf Pipe Line Company, extending from Wortham, Texas, east. The field office is at Fairfield. M. E. "Panama" Shiflett is general superintendent, Gene Coulter spreadman, Cooney Shiflett assistant spreadman, Ernest Smith and L. S. Hooks office, and J. O. Doggett master mechanic.

Mannix, Ltd., Calgary, Alberta, Canada, has in progress 224 miles of 24-in. pipe line for Trans-Mountain Oil Pipe Line Company, extending from Blue River to Coquihalla Pass, British Columbia. The field office is at 412 Victoria Street, Kamloops, British Columbia. C. P. Baker is project manager, "Curley" Wilkerson spreadman, and H. Eisler office manager.

H. L. Gentry Construction Company, 921 East Michigan Avenue, Jackson, Michigan, is laying 77 miles of 16-in. pipe for Buckeye Pipe Line Company, which is scheduled for completion about October 15. The work is between Allentown, Pennsylvania, and Linden, New Jersey, with the field office at Coopersburg, Pennsylvania. Frank Morris is general superintendent, Dick Coulson assistant superintendent, A. J. Brown spreadman, John Shafer office manager, and Russell Hilts master mechanic.

In the vicinity of Syracuse, New York, 20 miles of 10, 12, and 24-in. pipe is being laid for Niagara Mohawk Power Company. The field office is at Syracuse. R. L. Cantrell and Vern Curtis are spreadmen and Bob Groth office manager.

Fulton and Brodie Construction Company, P. O. Box 2064, Amarillo, Texas, working on 142 miles of 20-in. for Platte Pipe Line Company, is shut down for lack of pipe. Work is expected to be resumed by the middle of September. The section is between Holdrege and Odell, Nebraska.



Pipe Line Contractors

P. & S. Constructors, Inc., Cape Girardeau, Missouri, are laying 276 miles of 14-in. line from Wood River, Illinois, to East Chicago, Indiana, for the Shell Oil Company. The field office is at Peotone, Illinois. A. G. "Arkie" Hobson is superintendent, and V. E. Connor office manager.

Hourton Contracting Company, 2707 Ferndale Place, Houston, Texas, has the following construction work under contract:

Approximately 16 miles of 12-in. and 51 miles of 16-in. crude oil lines in Louisiana for Interstate Oil Pipe Line Company. The field office is at Houma. H. L. Leake is superintendent, S. B. Harrison assistant, and H. C. MacWhinnie office manager. Work is in progress.

45 miles of 30-in. from the vicinity of Eros, Louisiana, to the vicinity of Coldwater, Louisiana, for Tennessee Gas Transmission Company. The field office is at Jonesboro. F. A. Silar is superintendent, L. F. Redfearn office manager, and A. E. and F. E. Swanson master mechanics.

Approximately 20 miles of 18-in. gas pipe line reconditioning for Texas Gas Transmission Corporation in two sections, one south of Memphis, Tennessee, and one in the vicinity of Wilmot, Arkansas. Field headquarters are at Memphis, with J. A. Cantrell superintendent and J. B. Stoddard office manager. Work in progress.

Approximately 46 miles of 26-in. for Texas Gas Transmission Corporation from Beekman compressor station to near Bastrop, Louisiana, north to the Mississippi River. Field office Eudora, Arkansas. W .H. Hayes is superintendent, M. L. Thompson assistant, and J. C. Strickler office manager.

Approximately 190 miles of 24-in. crude oil line for Rancho Pipe Line Company from a point west of Austin, Texas, to Shell Oil Company's Deer Park refinery near Pasadena. Oklahoma Pipe Line Constructors, as a joint venture, are laying 64 miles from Deer Park refinery west to the Brazos River. With 18 miles to lay shortage of pipe caused this contractor to shut down but resumption of work was scheduled for September 1.

Britton Bros. Contracting Company, 812-13 Dan Waggoner Building, Fort Worth, Texas, is doing considerable pipe work inside the Sinclair refinery at East Chicago, Indiana, and laying 13½ miles of 22-in. pipe from the refinery south. This is on Sinclair's new pipe line system from Drumright, Oklahoma. The 13½ miles is through the congested area of East Chicago. Fred Byers is in charge of the work.

Britton Bros. Contracting Company is a new firm, as told elsewhere in this issue, formed by J. C. and Herbert Britton. J. C. Britton sold his interest in Britton Contracting Company, Inc., of Washington, Pennsylvania, to Roy Clark some six months ago.

Jayhawk Construction Company, Inc., P. O. Box 419, Great Bend, Kansas, on August 18 began laying 40 miles of 6, 8, 10, 12, and 16-in. pipe in a gathering system for Kansas-Nebraska Natural Gas Company. The work is in the vicinity of Lakin, Kansas. M. A. Nichols is superintendent and Morgan Blair office manager.

Bishop and Lock Construction Company, 1018 Magnolia Building, Dallas, Texas, began work the middle of August on 60 miles of 3, 8, and 10-in. pipe line from the Oletha field to Waco, Texas, for Ebasco Services Incorporated. The office is at 205 Brown Building, Groesbeck, telephone 237. The warehouse is at the Eubanks Welding Shop. Johnny McMahan is superintendent and W. H. Bond office manager.

The Texas-New Mexico Pipe Line Company job will be completed within the next few days. This consists of 29 miles of 8-in. and 5 miles of 6-in. between Eunice and Lovington, New Mexico. The field office is at 115 East Dunham Street, Hobbs. Howard Laquey is superintendent and M. E. Williams office manager.

Piggott Construction Alberta, Ltd., Edmonton, Alberta, Canada, got underway the latter part of August on 57 miles of 6-in. pipe for the Saskatoon Pipe Line Company, Ltd., from Milden, to Saskatoon. J. E. Flavin is project manager, D. Meyers spreadman, and Al Maley office manager.

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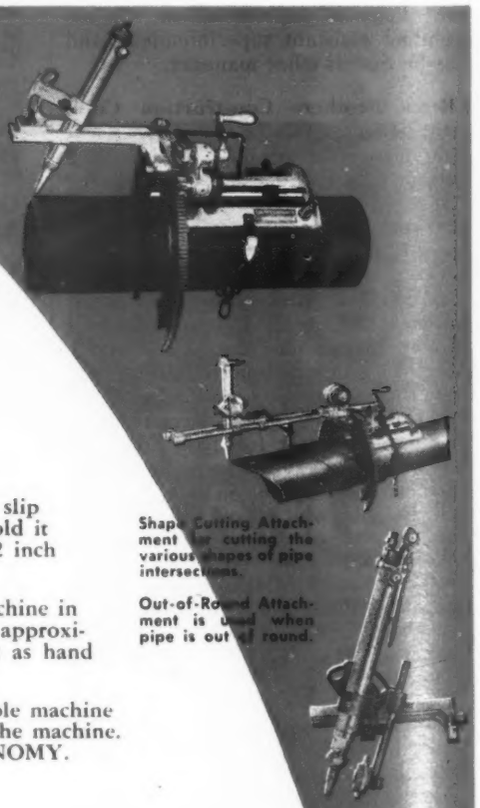

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Records Topple in 1951 Financial Analysis Shows

THE year 1951 was the most successful year in the history of the petroleum industry in the United States, as new records were established in sales, dividends, crude production and refining, wages and tax payments, according to a survey by the Chase National Bank of the City of New York. The study, "Financial Analysis of 30 Oil Companies for 1951," prepared by Frederick G. Coqueron of the Petroleum Department of the Chase, covers in detail the financial and operating activity of a group of companies that comprise about two-thirds of the industry in the United States.

The combined net earnings of the 30 companies increased 20 per cent over the previous year, from $1739 million in 1950 to $2090 million in 1951. Total income amounted to $18,307 million, an increase of 18 per cent over the previous year, while operating costs and other expenses amounted to $14,905 million, an increase of 15 per cent over 1950.

Preferred and common stock dividends declared by the 30 companies totaled $838 million, which is the largest amount on record and $152 million more than were declared in 1950. This disbursement represents 40 per cent of net income. Common dividends per share averaged $3.56 in 1951 against $3.18 for 1950.

The combined domestic and foreign net crude oil production of the group reached a new high of 4,221,000 bbl per day, surpassing the previous record made in 1948 by 10 per cent and the 1950 rate by 15 per cent.

Domestic production contributed 3,209,000 net barrels per day which represents 52.2 per cent of the production for the entire industry in the United States. Combined with their gross production, the 30 oil companies through investments in non-consolidated companies outside the U. S. produced a total of 6,180,000 bbl per day or 57.3 per cent of the world-wide production, excluding Russia and satellite countries, of 10,766,000 bbl per day. The volume of crude oil processed by the 30 companies established another new record, averaging 6,408,000 bbl per day, which was an increase of 12 per cent over 1950. Of this amount, 5,549,000 bbl per day were refined domestically and represents 85 per cent of all the refining operations in the U. S. Including the operations of non-consolidated companies, the 30 oil companies processed a total of 7,227,000 bbl per day, or 68 per cent of the volume of the entire industry throughout the world.

Total taxes charged to income by the group came to $1668 million, or about 10 per cent of total income, compared with $1150 million for 1950, an increase of 45 per cent. The companies also collected consumer taxes on its products for various governments amounting to more than $2 billion.

Expenditures for plant, property, and equipment by the 30 oil companies totaled $2540 million during 1951, an increase of 34 per cent over the previous year and only $152 million less than the all-time high spent in 1948. In the 6 years since the end of World War II, this group of companies has spent nearly $13 billion on plant, property and equipment, of which over $6 billion was reinvested earnings.

Year	Capital expenditures, million dollars	Capital extinguishments, million dollars	Excess of Capital expenditures, million dollars
1951....	2540	1511	1029
1950....	1894	1258	636
1949....	2263	1224	1039
1948....	2692	1146	1546
1947....	2156	905	1251
1946....	1422	793	629
ffTotal	12967	6837	6130

The companies obtained funds aggregating $316 million from banks, insurance companies and public investors in 1951. Some $258 million represented borrowings and $58 million the sale of common stock. Working capital of the group increased $492 million, from $3852 million to $4344 million, principally because cash generated from operations was $202 million in excess of requirements. The year 1951 in relation to 1945 shows that total assets of the 30 companies increased 88 per cent, capital employed 83 per cent and gross operating income 137 per cent.

Distribution of dollar income of 30 oil companies years 1951 and 1950.

	1951 cents	1950 cents
Operating costs and expenses	70.7	72.3
Depreciation, depletion and other charges	8.3	8.6
Income and other taxes	9.1	7.4
Income applicable to minority interests	0.5[1]	0.5[1]
Dividends to stockholders	4.6	4.4
Reinvested in business	6.8	6.8
Total income	100.0	100.0

[1] Of this amount, 0.2 cents were paid to minority stockholders as dividends and 0.3 cents were reinvested.

In analyzing the entire industry in the United States, Coqueron estimates the gross assets of the petroleum industry at $36 billion. The gross volume of business in 1951 was approximately $16.7 billion, an increase of 11 per cent over 1950.

The survey shows the world-wide demand for petroleum products, again excluding Soviet dominated countries, reached a new high of 11,200,000 bbl per day, a gain of 57 per cent over the 7,100,000 bbl per day consumed in 1946. During this period since the close of World War II, demand in the Western Hemisphere has increased at an average annual rate of 8 per cent, lagging behind the annual average increase of 14 per cent in the Eastern Hemisphere.

One of the most significant developments in the world oil picture during 1951 was the ability of the petroleum industry to replace the production lost by the shutdown of the Iranian oil fields, which had contributed an average of 661,000 bbl per day or 6 per cent of the world supply during the first six months of 1951. * * *

Summary of United States petroleum statistics years 1951, 1950 and 1949.

	Thousand barrels per day			Change 1951 from 1950 percent
	1951	1950	1949	
SUPPLY-ALL OILS				
Domestic production				
Crude oil	6149	5407	5046	+13.7
Natural gas liquids	564	499	431	+13.0
TOTAL DOMESTIC PRODUCTION	6713	5906	5477	+13.7
Crude oil imports	491	487	421	+ 0.8
Refined product imports	352	363	225	— 3.0
TOTAL SUPPLY	7556	6756	6123	+11.8
DEMAND-ALL OILS				
Domestic demand	7032	6507	5803	+ 8.1
Crude oil exports	78	95	91	—17.9
Refined product exports	345	210	236	+64.3
TOTAL DEMAND	7455	6812	6130	+ 9.4
Change in stocks	+101	—56	—7	....
CRUDE RUNS TO STILLS				
Domestic	5996	5257	4903	+14.1
Foreign	498	482	423	+ 3.3
TOTAL RUNS	6494	5739	5326	+13.2
CRUDE OIL IMPORTS				
Venezuela	294	295	275	— 0.3
Middle East	103	114	101	— 9.6
Other Countries	94	78	45	+20.5
TOTAL IMPORTS	491	487	421	+ 0.8
AVERAGE PRICES				
Crude oil (per barrel)				
All grades (Bureau of Mines)	$2.52	$2.51	$2.54	+ 0.4
Gasoline (per gallon)				
Dealer tank wagon (50 cities)	15.33c	15.10c	15.05c	+ 1.5
Tank car (9 markets)	11.66c	11.30c	11.17c	+ 3.2
BUREAU OF LABOR STATISTICS INDEX				
Refined products 1947-49<100	110.6	103.7	100.1	+ 6.7
All commodities 1947-49<100	114.8	103.1	99.2	+11.3

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THE IDEAL® TYPE 16

Ten years ago an engineer's dream—
six years later an Oil Show highlight—
today the IDEAL Type 160 Consolidated Rig is the heavyweight champion in drilling equipment.

Designed to probe subterranean depths of 20,000 feet and over, and to be of unmatched ruggedness in toughest drilling at any depth, the Type 160 represents the oil industry's aggregate knowledge of everything that equipment for ultra-deep drilling must embody.

Powerful draw-works, hoisting tackle, diesel engines and pumps, with the last word in automatic control equipment and related heavy-duty tubular products, are brought together in a custom-built team of unusual stamina, flexibility and responsiveness. Together they combine technical advances never before built into *any* drilling equipment.

Yet, all the outstanding features of this 20,000 foot power drilling rig are secondary to the economic purpose of its existence. The basic design concept of the Type 160 stems solely from the hard fact that the oil industry, as it pushes exploration to greater and greater depths, must minimize its dollar risk with drilling equipment of maximum *over-all* economy. (The fallacy of low first cost has been quickly exposed in this hard-fought contest with Nature, where the odds are great and the stakes keep growing higher.)

Hence, in the IDEAL Type 160 Consolidated Rig, you will find that the governing purpose of its design is to combine truly adequate power, speed, dependability and efficiency to achieve *lowest cost per foot of hole.*

If you have a project involving *deep* drilling or *hard* drilling, on water or land, with greatest possible *over-all* economy, the IDEAL Type 160 Rig is well worth investigating. It helps to illustrate, once again, why The National Supply Company is today the world's largest manufacturer of oil field machinery and equipment.

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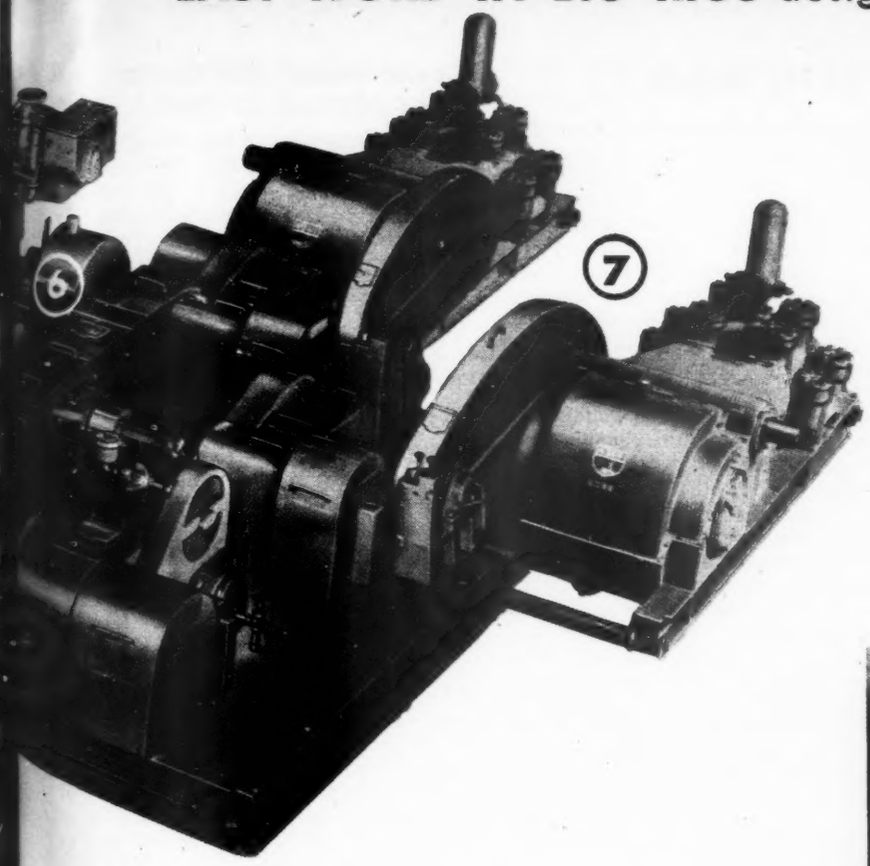

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4 Ideal Universal Cathead
5 Superior Supercharged Diesel Drilling Engines
6 Ideal-Gyrol Fluid Drive
7 Ideal Duplex Power Pump
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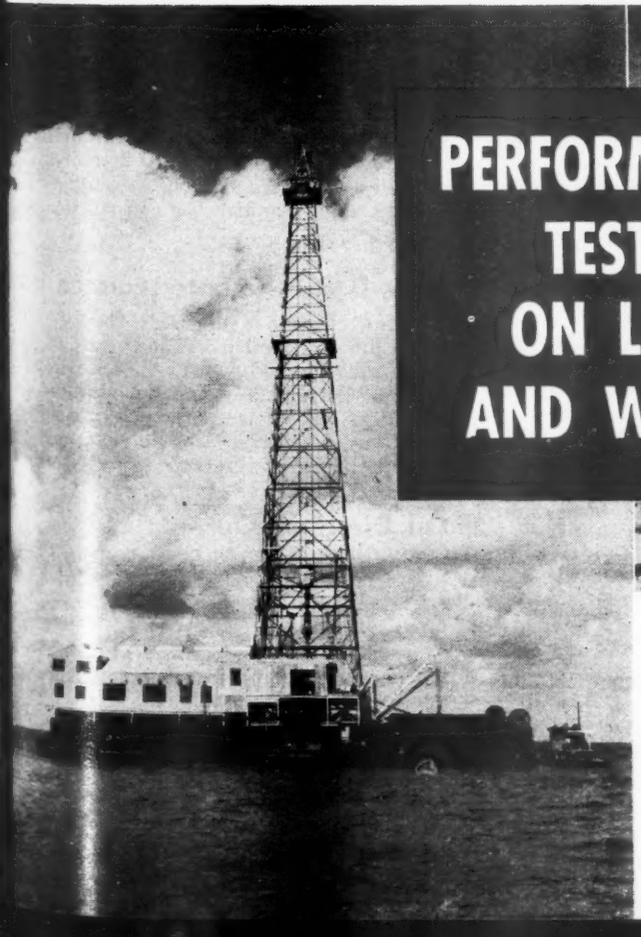


The first Type 160 Consolidated Rig to be manufactured helped set a new world's record in 1949 by drilling 20,521 feet in Wyoming under some of the most difficult conditions of both underground structure and weather.

The versatile Type 160 Rig on a drilling barge in Louisiana. This installation in constant use for over 2 years is believed to make a new record in drilling capacity for floating rigs.

Sharp Denials Stem from Release of FTC Report

Sharp denials and protests from representatives of several oil firms greeted the Federal Trade Commission report upon its release to the public recently. Although the report was admittedly toned down for diplomatic reasons, it is still strong enough to cause considerable furore here and abroad.

The FTC report charged the seven oil firms involved in the case with being the main force behind the setting of production quotas in the oil fields of the U. S. to help exploit and protect their more profitable oil holdings in the Middle East. Oil allowables are set by the various states in the interest of conservation.

"These seven international companies operate through layers of jointly owned subsidiaries and affiliates, the 378-page document read. "Through this corporate complex of companies, they control not only most of the oil but also petroleum refining, cracking, transportation, and marketing facilities."

This arrangement allowed the companies to buy and sell among themselves in what amounted to bookkeeping transactions, giving them extra profits that were not passed on to their customers, said the report. The report also cited a number of agreements it claimed the oil firms worked out "to forestall in the future outbreaks of competition."

Attacking the U. S. oil quota restriction, the report claimed: "Conservation in the United States became the cartel's slogan at a time when a rising flood of international production threatened to depress world prices."

Accusations of overcharge were similar to the charges made before release of the report by the Mutual Security Agency, successor of Economic Cooperation Administration, that cartel price fixing has brought about exhorbitant overcharging to the U. S. for oil shipped to foreign countries under the Marshall Plan. Four of the companies, now under fire from the government for their participation in the alleged cartel, have been sued by the government for their supposedly overcharging of $67,000,000 on oil shipments.

An Attorney General James McGranery aide brought charges against Socony-Vacuum Oil Company, and its wholly owned subsidiary, Socony-Vacuum Overseas Supply Company, for the amount of $14,118,498; Standard Oil of New Jersey, for $31,795,619, and Standard Oil of California, and The Texas Company and their jointly owned subsidiaries, Bahrein Petroleum, California-Texas Oil, Caltex Oceanic, and Mid-East Crude Sales, for $21,477,722. Claims are said to represent overcharges between May, 1949 and May 31, 1952.

Included in the so-called cartel conspiracy with Anglo-Iranian Oil Company and Shell Oil Company to control world oil prices are: Standard Oil Company of California, The Texas Company, Socony-Vacuum Oil, and Gulf Oil Corporation.

In its denial of the charges, Socony-Vacuum Oil Company said that the secret FTC report "seems to be a part of a deliberate program to make this and other oil companies engaged in international trade 'whipping boys' during an election campaign," and criticized the manner in which the report had been handled.

Standard Oil of New Jersey said the report threatened to undermine American integrity abroad and endanger national security. A spokesman added that its record was clear and it would support that record before the people and a grand jury.

"Insofar as Gulf Oil is concerned the report is not based on fact," a Gulf spokesman reported, adding "Gulf is not a party to any cartel arrangement, either international or otherwise."

In a statement to the press, Texaco declared in part:

"The policy of The Texas Company is to obey the law. The Texas Company is not a party, either directly or indirectly through any subsidiary or affiliated company, to any international oil cartel or any price-fixing arrangement of any kind, or any monopoly, whether international or domestic, nor do we believe that other oil companies are involved in any such cartel."

According to Senator Ferguson of Michigan, the FTC report is mainly a re-hash of the findings of a Senate group that he headed in 1948, "neither new nor very surprising."

NACE Meeting to Consider Offshore Structure Corrosion

Technical information on the prevention of corrosion of offshore oil well drilling structures, marine tankers, and how mill scale affects the corrosion rate of steel in salt water and the effect of bacterial corrosion in sea water are included in the program of the South Central Region, National Association of Corrosion Engineers' October 1-3 meeting at New Orleans. Eighteen technical papers in four symposia have been outlined by Technical Program Chairman John E. Loeffler of Thornhill-Craver Company, Houston.

API Eastern District Meeting Date Changed

The Division of Production of the American Petroleum Institute has announced that the date for its 1953 Eastern District meeting has been changed to avoid conflict with another trade association meeting. Currently scheduled for April 15-16-17 in the William Penn Hotel, Pittsburgh, Pennsylvania, the API meeting will be held instead on April 8-9-10.

Scholarships Set Up

Standard Oil Company (Indiana) has established 14 undergraduate scholarships in liberal arts colleges in the midwestern states in which it operates. This will further the training of technical personnel, Dr. Robert E. Wilson, chairman of the board, announced.

Soviet Report Oil Quota Was Fulfilled in 1951

Soviet Minister of Petroleum Baibakov has reported that the USSR successfully fulfilled its quota in oil development last year. This was announced in the *International Petroleum Trade*, a monthly publication of the U. S. Department of Interior, Bureau of Mines.

In 1950 the Soviet petroleum industry reported a production of 273,000,000 bbl, and in 1951 Soviet Minister of the Interior Beria spoke of a yearly average increase in output of 32,700,000 bbl, so the 1951 total can be calculated to have reached 305,000,000 bbl the report stated. Baibakov added in his report that new oil fields had been discovered and new oil horizons opened due to extensive geological prospecting.

A number of large petroleum refineries with a throughput capacity of 125,000 bbl daily were put into operation in Russia last year, according to Baibakov, along with new petroleum and natural-gas pipe lines. Baibakov emphasized the large increase in capacity of the Soviet refineries, which can now deliver improved products because of their modernized equipment. Gross production of the machine shops of the Ministry of Petroleum rose 22 per cent over that of 1950, the International Petroleum Trade reported, and the productivity of the labor force of the petroleum enterprises increased 8 per cent.

Baibakov admitted, however, that considerable difficulties had arisen in the drilling. In the eastern areas the drilling, in spite of extensive utilization of turbine drilling, was hampered by the hardness of the rocks to be penetrated.

PAD to Conduct Survey

The Petroleum Administration for Defense has announced it will conduct a survey to get latest figures on the nation's petroleum industry's refining capacity. Refineries throughout the country will receive questionnaires shortly, PAD announces, which will ask refiners about all phases of petroleum-product manufacture. The survey will include a tally of all existing refining capacity as well as that planned for construction through 1954.

New D & D Chapter Formed

A new chapter of the Desk and Derrick Club of America has been formed at Bartlesville, Oklahoma. Alice Eakin, Phillips Petroleum Company, Bartlesville, was elected temporary chairman, and Gladys Muder, Cities Service, was made temporary secretary.

Oil Directory Out

Joe H. Green, Oil and Gas Directory, Inc., has announced publication of the 1952-53 edition of *The Oil and Gas Directory*. Published from 1947 to 1951 as *The Texas Petroleum Directory*, the book was expanded to include Oklahoma, New Mexico, and Louisiana and the name changed at that time to *The Oil and Gas Directory*.

June Gasoline Reserves Up 36 Per Cent From Year Ago

Federal revenues from excise taxes on gasoline were 36.9 per cent higher in June than they were a year ago, the Internal Revenue Department has reported. Taxes on gasoline reached a total of $71,743,464 for the month of June, $19,364,052 above those of June last year. Tax on lubricating oil in June brought in $11,376,344 or 8.1 per cent more than the same month last year, and transportation of oil by pipe line paid Federal taxes of $2,135,482 in June, a 16 per cent gain from the $1,841,503 brought in by that source in the 1951 month.

Petroleum Exports Out

The Petroleum Administration for Defense has made public the following summary of exports of major petroleum products from the United States. Figures, given in thousands of barrels daily, include products exported by tanker and barge movement only.

Week ending	Avgas*	Motor gasoline	Kerosine	Distillate	Residual	Total
June 27....	29.2	56.2	31.8	135.1	142.5	394.8
July 4.....	43.7	2.7	24.7	40.2	61.7	173.0
July 11....	42.4	14.8	17.3	74.9	46.1	195.5
July 18....	26.8	16.1	0.6	57.1	91.4	192.0

* Avgas is partly estimated and includes all methods of shipment.

U.S. Crude Imports Rise

Crude oil imports to the United States have risen for the third straight week during the period ending August 9, the American Petroleum Institute reports.

Set out below are figures indicating the imports of crude oil and petroleum products for the week of August 9 and the four weeks period ended that date.

Week ended	Crude oil	Residual oil	Others	Total
	(Figures in barrels per day)			
July 19.....	502,200	263,700	29,900	795,800
August 2....	650,100	211,500	29,700	882,300
August 9....	767,800	184,700	18,000	970,500

Publishes Crude Prices

Creole Petroleum Corporation has announced it is publishing prices at which it will sell and purchase Venezuelan crude oils f.o.b. Venezuelan deep water terminals. Arthur T. Proudfit, Creole's president, announced that because Venezuela is now the largest petroleum exporting nation in the world, there should be published prices for petroleum at Venezuelan ports.

In accordance with this plan Creole has published prices at which it will sell and buy Venezuelan crude oil in cargo lots at Venezuelan deep water ports subject to crude availability and Creole's requirements. Prices range from $2.95 per barrel for Cumarebo crude to $1.40 per barrel for Pedernales crude. Any purchases of Venezuelan crude oil made by Creole that are not subject to contracts with the Government will be made at the price established by schedule currently in effect.

Hale Booklet Reports on Oil Industry Financing

Producers, refiners, and distributors of oil and petroleum products obtained $96,723,000, petroleum pipe lines $129,500,000, and oilwell tool and supply houses $35,300,000 from life insurance companies and other long-term investing institutions in 1951. Purchases of tank cars were financed to the extent of $68,948,000. Thus the oil industry and related lines received a total of $329,471,000, according to The 1952 Yearbook of Private Placement Financing, published June 30 by E. V. Hale and Company, Board of Trade Building, Chicago.

Largest private financing for pipe lines was an issue of $57,000,000, 3.375 per cent 25-year first mortgage bonds sold to two life insurance companies by Platte Pipe Line Company. Transmountain Oil Company placed $35,000,000, 4 per cent 20-year bonds with an insurance company through two intermediaries, and it was announced that Buckeye Pipe Line Company had obtained a commitment for $30,000,000 on 3.50 per cent 20-year debentures from a group of lenders. Other pipe lines financing privately were Triangle Pipeline Company, $6,000,000; and Tuscarora Oil, Ltd., $1,500,000.

Twenty-four producers, refiners, and distributors of petroleum and its products included 12 companies which obtained 18 oil and gas production loans totalling $51,431,000. Included among those receiving production loans were GMB Oil Corporation ($19,500,000), Unitoils, Inc., ($11,000,000), Devonian Company ($5,310,000), Brazoria Company ($3,850,000), La Gloria field ($2,150,000), Poppy Oil Company ($2,713,000), American Liberty Oil Company ($2,000,000), et al.

Largest loan to an oil producer (apart from production loans above) was $14,000,000 obtained by Delhi Oil Corporation from an insurance company and three banks, the yearbook reports. Other borrowers included Ashland Oil and Refining, $10,000,000; Taylor Refining, $10,200,000; Deep Rock, $2,500,000; Roosevelt Oil and Refining, $2,500,000; Derby Oil, $1,500,000, and Shamrock Oil and Gas, $1,000,000, et al.

In the oilwell tool and supply field the largest borrower was A. O. Smith Corporation, makers of casing, with $25,000,000, 3.75 per cent 15-year notes. Others included Byron Jackson, $6,800,000; Midcontinent Supply, $2,500,000, and Republic Supply, $1,000,000.

With the exception of $20,000,000, 3.75 per cent 20-year serial notes sold by General American Transportation Corporation through an intermediary to three life insurance companies, and $9,000,000, 4 and 12-year notes sold to two banks and an insurance company by North American Car Company, all the tank car financing took the form of equipment trust certificates. General American placed three issues of these on a 3.125 per cent 20-year basis through an intermediary, aggregating $24,182,000. Warren Petroleum placed two 15-year issues aggregating $15,766,000 at 3.50 per cent with two institutions.

NPC Group to Study Offshore Oil Prospects

Walter S. Hallanan, Chairman of the National Petroleum Council, announced the appointment of a Committee on Submerged Lands Productive Capacity to study and report on the oil and gas prospects of offshore submerged lands on the basis of technological aspects only without regard to ownership or title.

The Department of the Interior's Oil and Gas Division, according to Hallanan, requested such a study stating that the problems incident to the discovery, development, and production of offshore petroleum deposits are different both in magnitude and in character when compared to operations in adjacent onshore areas.

The Committee is headed by L. S. Wescoat, president of the Pure Oil Company, Chicago, Illinois.

Steel Strike Effects Linger

Settlement of the steel strike has brought little immediate relief from the steel shortage in the oil industry, although steel is beginning to trickle in from the mills. Another thing that could cause a serious setback is the steel industry's shortage of ore. There is not enough ore at the furnaces to keep running all winter, as shipments of ore were halted during the strike. Ore boats go into docks for the winter when the Great Lakes freeze, so an early winter could be injurious to the industry.

Some oil producers believe it will be Christmas before normal development programs can be carried out and some think it may take until Easter. Russell Brown, general counsel for the IPAA, says he does not believe the drilling losses can be made up this year. An estimated domestic loss of 8000 new exploratory wells is the result of the strike, plus 1000 new exploratory foreign and Canadian wells. Another loss is the delay of refinery, crude oil pipe line and storage expansion projects, and expansion of natural gasoline plants, which results in an estimated loss in production of 900,000 bbl of natural gas liquids below the estimated 1952 production.

Conoco Gets Safety Awards

Continental Oil Company this week marked four years without a fatal accident, and, at the same time, two company refineries at Lake Charles, Louisiana, and Glenrock, Wyoming, completed five years without a lost-time accident, it was announced by J. S. Boylan, director of Continental's safety division. Boylan also reported that Conoco's refinery at Wichita Falls, Texas, recently recorded one year without a lost-time accident.

GRADUATE METALLURGICAL ENGINEER desires position as Corrosion Engineer; nine years' experience in Automotive and Pipeline Field. Box 144, c/o The Petroleum Engineer, P. O. Box 1589, Dallas, Texas.

Oil Firms' Net Income Down, Most Six-Month Reports Show

A study of a number of U. S. oil firms show higher gross incomes for the first half of 1952, but lower net returns. Main reason given for lower incomes were increased costs of operating due to the inflationary trend of the times, fixed price ceilings on products, and prolonged strikes in refineries in the early part of the spring. Decreases in production and refinery runs were also seen in the reports, mainly due to strikes.

Atlantic Refining—Gross income for the 6-month period totaled $290,080,857 compared with $269,822,905 for 1951. Net income totaled $21,933,764 slightly above the $20,724,317 for 1951.

Bishop. Gross income totaled $840,737 compared with $928,682 for the comparable period last year. Net profit was $51,667 compared with $158,607.

Cities Service. Net income totaled $27,120,714 compared with $32,679,216 for the like period last year.

Continental. Gross income reported amounted to $190,890,000 for the first six months this year, compared with $185,417,000. Despite increased gross income, however, net profit was down to $17,099,000 from $22,033,000.

Deep Rock. Six months reports showed a loss in net income this year of $96,000; 1952 figure was down to $890,000.

Derby Oil. Gross operating income for this year's first six months totaled $7,707,870 compared with last year's $8,297,238. Net income dropped to $382,399 from $915,453.

Gulf Oil. Higher net earnings were reported for the first six months of this year. $66,981,000 compared with $63,319,000 last year.

Honolulu Oil. Gross operating income totaled $11,839,269 the first six months this year compared with $12,151,268 last year. Net income totaled $3,744,196 compared with $3,644,381.

Houston Oil. Higher gross income and lower net income was the result of Houston Oil's activities the first six months this year. Gross revenue totaled $12,929,587 as against $12,479,603 last year. Net income for the period was $3,010,224, compared with $3,487,767.

Humble Oil and Refining. First half of the year gross income totaled $488,753,900 compared with $461,520,300 first half last year. Net income was $74,992,600 compared with $89,313,500.

Lion Oil. Net income for first half of this year totaled $5,548,122, compared with $5,744,053 first half last year.

Maracaibo Oil. Gross revenue this first six months totaled $259,261 compared with $239,364 last year. Net income totaled $110,579 as against $318,968, which included capital gain on sale of stock interest in Gulf Plains Corporation.

Middle States. Net income $1,104,000 compared to $1,800,000 same period last year. Gross income totaled $5,144,700 compared with $5,059,500.

Mid-Continent Petroleum. Gross income figured $84,966,411 compared with $75,201,851 same period last year. Net income was $8,160,563 compared with $8,975,961.

Ohio Oil. Net income for first half 1952 totaled $20,360,622 as against $19,776,750.

Phillips Petroleum. Gross income totaled $346,508,597 compared with $287,163,175. Net income totaled $38,933,442 compared with $34,002,597 last year.

Richfield Oil. Net income for first half this year totaled $11,731,195 compared with $14,997,075 last year.

Shell Oil. Net income for the first six months of this year reached $42,554,913 compared with $45,220,846 same period last year.

Sinclair Oil. Gross operating income totaled $415,631,931 first six months this year and $389,805,670 same period last year. Net income was $44,589,701 as against $38,107,501.

Skelly Oil. Gross income totaled $49,195,274 first half this year, compared with $48,346,504 last. Net income was down $5,864,961 compared with $7,144,405.

Socony-Vacuum. Net income for 1952 totaled $84,000,000 compared with $76,000,000 first half 1951.

South Penn. Net income of $3,743,977 for first six months this year compared with $4,226,901 first half 1951.

Standard of Indiana. Net earnings totaled $57,813,880 down from the $71,068,606 reported for first half last year. Gross incomes, however, rose from $766,718,420 to $733,172,254.

Tide Water. Semi-annual net income totaled $15,354,926 as against $17,223,331. Gross income totaled $215,153,554 as against $199,778,215.

Oil and Gas Law Institute Program Is Announced

The Southwestern Legal Foundation at Dallas, Texas, announces the program for the Fourth Annual Institute on the Law of Oil and Gas and Taxation to be presented January 21 through 23, 1953. The Institute will deal with the economics of the oil and gas industry; practical and legal problems in delay rental and shut-in royalty payments; rights and remedies for non-development and failure to off-set; federal regulation of interstate shipment and sale of gas; and the present and future prospects for natural gas.

Awards Scholarships

Thirteen sons and daughters of Cities Service Oil Company (Delaware) employees have been awarded scholarships by the Henry L. Doherty Educational Foundation, a Cities Service supported organization. The scholarships will be applied at a college selected by the student. Renewed scholarships were also granted to 17 additional students enabling them to continue their college studies.

Bottled Gas Demands Up

Demand for bottled gas in 1951 practically doubled the volume of four years earlier, the U. S. Bureau of Mines has reported. Last year, liquefied petroleum gas sales were 21 per cent higher than in 1950, which in turn were 23 per cent higher than 1949. LPG exports also climbed sharply, the B of M reports. Demand increased 17 per cent in 1949. 27 per cent in 1950; 29 per cent in 1951.

NPC Terms B of M Synthetic Report Misleading

The National Petroleum Council's Committee on Synthetic Liquid Fuels Production Costs has presented its analysis of the Ebasco Services, Inc., report prepared for the Bureau of Mines, analyzing Bureau hydrogenation cost figures.

The Council says that statements circulated in April misled the public into believing that Ebasco concluded that industry could finance, build, and operate a coal hydrogenation plant that could give the motorist a synthetic gasoline equal to today's motor fuel in quality and competitive with the present cost.

The Council pointed out, the Ebasco report in its principal economic conclusion says:

"We do not believe it would be feasible to finance the projects described in the Bureau of Mines Report dated October 25, 1951, with private capital under conditions prevailing at January 1, 1951."

The Council says Ebasco pointed out that to make the venture attractive, a return of about 15 per cent after taxes should be realized. This would result in a gasoline cost of 28 cents per gallon.

In contrast to this, the Council has been conducting a half-million dollar survey of synthetic liquid fuels costs which incorporates estimates made by coal industry, finance, housing, and petroleum industry experts. This survey placed the actual manufacturing cost at 41 cents per gallon.

The Council said, however, that oil men are talking about a true synthetic fuels plant—not a plant where synthetic fuels are a by-product of a chemicals operation. It is largely on this point that the Council and the Bureau of Mines differ in the matter of arriving at cost.

The Council quoted the Ebasco report as finding that the Bureau of Mines hypothetical plant would derive 53 per cent of its income from the sale of chemicals. The Council emphasized this percentage would be too large, due to overproduction of chemicals when supplying even a moderate percentage of the nation's fuels.

Secretary of the Interior Oscar Chapman has complained in a report to congress that there have been no takers of offers for government aid to build a synthetic plant. In a report to Congress he urged private industry to go ahead and develop commercial plants for transforming oil shale and coal into gasoline and other synthetic fuels as soon as possible. His report estimated it would cost $872,150,000 to $1,184,000,000 to develop a 250,000-bbl a day oil shale industry using the gas combustion process developed by the Bureau of Mines.

DEATHS

W. A. Berryman, 61, vice president in charge of foreign marketing for Gulf Oil Corporation, and a director of a number of its foreign marketing subsidiaries, died in Presbyterian Hospital, August 3 after an extended illness.

Berryman joined Gulf in 1933 in the foreign marketing department, and was sent to Antwerp, Belgium, where he was actively associated in the organization and management of some 30 marketing subsidiary companies. Following the outbreak of World War II, he returned to the company in Pittsburgh; and in 1945 was named assistant to the vice president in charge of foreign marketing. He was elected a vice president of Foreign Marketing department in May, 1949.

Lammot du Pont, former president of E. I. du Pont de Nemours and Company and youngest of the three brothers who led the twentieth century development of the 150-year-old chemical company, died July 24. He was 71 years old. Illness that had confined him to his Fishers Island, New York, summer home for several weeks kept him from the side of his two brothers, Pierre and Irenee, recently, at the company's 150th anniversary ceremonies on the site of the original powder mill on Brandywine Creek here. Lammot du Pont was the eighth member of the du Pont family and the third brother in succession to become head of the chemical company founded by Eleuthere Irenee du Pont de Nemours, his greatgrandfather, in 1802.

George W. Evans, a 30-year employee of Continental Oil Company, died of a heart attack July 28 at his home in Fort Worth, Texas. Evans joined Continental Oil Company at Ponca City, Oklahoma, in 1922, in the purchasing department. He was promoted to assistant purchasing agent in 1924; became general purchasing agent in 1939, and was promoted to coordinator of pipe lines and manager of purchasing in 1949.

Fred H. Matthews, manager, crude and products department, and member of the western division operating committee, Tide Water Associated Oil Company, died at his home in Oakland, California recently. Matthews, had been employed by Tide Water Associated for more than 39 years. He began as an office boy in the company's San Francisco general office, and during his employment with the company held many important administrative positions.

Dr. E. W. Bodine died suddenly August 11. A well-known plant pathologist he had been in charge of the agricultural products development section for the western division of Shell Chemical Corporation in San Francisco. He had planned to leave immediately for Denver, Colorado, to take up his new product development assignment for Julius Hyman division, Shell Chemical Corporation, engaged in the manufacture of insecticides and soil fumigants. Dr. Bodine received both his BS and MS degrees in plant science at Colorado State College, Fort Collins, Colorado. He earned his Doctor's degree at the University of California by doing graduate study in plant pathology.

Sheldon Clark, chairman of the board of directors, Sinclair Oil Corporation, died August 15 in Passavant Hospital after a long illness. He had been chairman of the board since 1951 and a member of the board since 1925.

Ward Payne Anderson, general manager of the refining division, eastern operations, of the California Texas Oil Company, died suddenly August 12. Anderson was graduated from the University of California with a BS degree in chemical engineering and in 1925 he joined the research and development department of the Richmond, California, refinery of the Standard Oil Company of California, one of the parent companies of the California Texas Oil Company, Limited.

Ralph W. Gallagher, former president and chairman of the board of Standard Oil Company (New Jersey) died July 31. He began in the oil business in Olean, New York, in 1897 as an oiler and retired as chairman of the corporation's board in 1945. He continued, however, as a director of the J. P. Morgan and W. T. Grant corporations.

H. E. Rockett, Magnolia Petroleum Company, died in Dallas, Texas, recently. He had been with Magnolia since 1913 and had only one more year to go until his retirement.

Caxton Brown, retired president of the Weston Electrical Instrument Corporation, died July 28. Brown had been with the Weston organization for half a century. He served as president from 1944 to 1947 after which he remained active as a member of the board of directors and executive committee chairman.

He joined the Weston Electrical Instrument Company in 1901 as a repairman. He rose through the ranks to become manager of the New York office two years later. In 1908 he was made secretary of the company and a member of the board of directors.

Brown attended Brooklyn Polytechnic Institute, Columbia Grammar School and was a member of the class of 1900 at Columbia University.

Harold Dunn, driller from Nowata, Oklahoma, died July 26. Dunn had retired in June from Basinger Oil Company with which he had been associated for 7 years. Earlier he and his brother, Blythe Dunn, formed Dunn Brothers Drilling Contractors.

Cecil Finn, personnel director for Superior Oil Company, and **Bascomb Land,** central division personnel director, Lafayette, Louisiana, were killed August 8 in an airplane crash near Bluemont, Virginia.

Harry Maxwell, 60, former manager of industrial relations for Sun Oil Company, died at his home in Ft. Lauderdale, Florida, August 9 after a long illness. Maxwell, a Sun employee for more than 32 years, joined the company in Dallas in 1919 as an attorney, but immediately was plunged into day-to-day operations of the production department. He was for six years in charge of a company office at Bakersfield, California, and also represented Sun in Venezuela.

He was a graduate of George Washington and Georgetown universities, holding bachelor of arts and bachelor of laws degrees.

Walter A. Schulze, 52, a member of the research planning board of Phillips Petroleum Company, died at Bartlesville, Oklahoma, July 30, following a short illness.

Schulze, a widely-known scientist, especially in the oil industry, joined Phillips in 1929, and shortly thereafter became chief chemist for the company. From 1945 to 1950, he was assistant director of the chemicals division of the research and development department.

He graduated from the University of Texas in 1925, and later took graduate work there and at the University of California.

Schulze was the author of numerous technical papers pertaining to the petroleum and chemical industries and contributed importantly to the development of many processes in widespread use today. He was granted more than 200 United States and foreign patents.

R. H. Griffin, 31, engineer with the oil production department of Cities Service Petroleum, Inc., New York City, died June 21, 1952, in Bartlesville, Oklahoma, of fatal injuries received in an automobile collision. Griffin first joined Cities Service as an evaluation engineer in 1939 following his graduation from Kansas State College and held various positions with the company until the time of his death when he was attached to the New York office.

Theodore Bockman, a chemical engineer with Universal Oil Products Company for nearly 18 years, passed away on July 30 in Chicago. Brother of George A. Bockman, treasurer of Universal, Theodore Bockman was well known throughout the petroleum refining industry both in the United States and in England where he recently spent several months on a special engineering assignment.

A graduate of Illinois Institute of Technology, class of 1925, Bockman was a member of the Alpha Epsilon Chapter of Phi Kappa Sigma fraternity, and of the Western Society of Engineers.

J. H. McClellan, office manager for the River Construction Corporation, Fort Worth, Texas, passed away August 9. Funeral services were in Fort Worth, August 11. He was 50 years old.

Personals

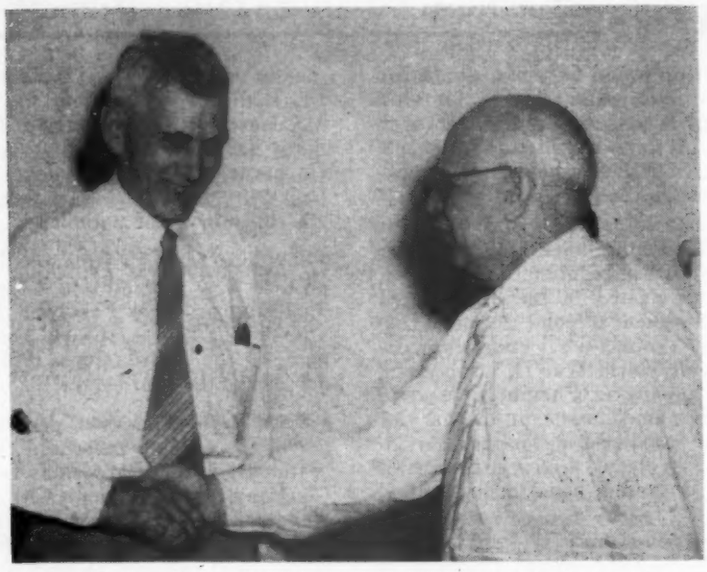
▸ **Harry C. Fowler,** Chief of the Fuels Technology Division of Region VI, Bureau of Mines, and Superintendent of the Petroleum Experiment Station at Bartlesville, Oklahoma, has been presented the Distinguished Service Award and Gold Medal of the Department of the Interior.

The presentation was made during ceremonies held at Bartlesville on July 31. R. A. Cattell, Chief of the Petroleum and Natural Gas Branch of the Bureau of Mines in Washington, D. C., presented the medal. Dr. C. W. Seibel, Regional Director of Region VI, Amarillo, Texas, read the citation and the nominating letter written by J. J. Forbes, Director, Bureau of Mines, Washington, D. C.

Fowler has written or co-authored nineteen technical articles pertaining to petroleum or natural gas in his 29 years with the Bureau.

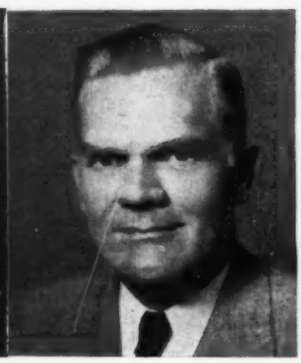
In 1923, Fowler was appointed safety engineer with the Bureau of Mines at Bartlesville, Oklahoma. Five years later he was called to Washington to serve as Acting Chief of the Petroleum and Natural Gas Branch. In 1945 he returned to Bartlesville as supervising engineer, and in 1950 became Chief of the Fuels Technology Division of Region VI, the position he now occupies.

Stated the citation: "Possessed of the rare combination of outstanding technical ability and the capacity to lead and direct, Mr. Fowler has made many technical contributions that were highlighted by his safety engineering. Particularly noteworthy is his work on the hazards connected with hydrogen sulfide in drilling and in handling crude oil and refined products. Several of his many publications relate to this prevalent hazard. His record as an administrator and supervising engineer of the largest Government petroleum experiment station in the world is an enviable one. For his technical achievements, devotion to the cause of conservation, and services to his fellow men, Mr. Fowler has earned the highest honor of the Department of the Interior, its Distinguished Service Award."



Harry C. Fowler, chief of the Fuels Technology Division, Region VI and superintendent of the Bartlesville Station, U. S. Bureau of Mines, receives congratulations from R. A. Cattel, chief of the Petroleum and Natural Gas Branch.

F. C. W. Paton



T. H. Wallace

R. P. Huggins

▸ **F. C. W. Paton** has been appointed general manager of foreign marketing for Gulf Oil Corporation according to an announcement by Gulf Chairman J. F. Drake and President S. A. Swensrud.

Prior to this promotion, Paton had been assistant to the late W. A. Berryman (See Deaths). In his present assignment he will be responsible for directing the company's marketing activities through some 30 subsidiaries operating outside continental United States. Paton is a graduate of the University of Pennsylvania. He joined Gulf in 1939.

▸ **R. P. Huggins** was named vice president of Gulf Oil Corporation and Gulf Refining Company. **T. H. Wallace** succeeds him as vice president of Western Gulf Oil Company, with offices in Los Angeles, California.

Huggins, heretofore vice president of Western Gulf Oil Company in charge of California operations, has been elected a vice president of Gulf Oil Corporation and of the Gulf Refining Company, the two companies announce. He will take charge of the crude oil purchasing activities of the two companies under general supervision of J. H. Russell, vice president in charge of pipe lines and crude oil purchasing. He will take up residence at Houston, Texas, where crude oil purchasing department is situated. He has been with Gulf for 31 years.

Wallace, a veteran of 26 years with Gulf was graduated from Texas A. and M. College. In 1929 he was transferred to the Houston division, production engineering department. He was stationed in the Los Angeles office in 1947, and in 1949 made manager of the exploitation department and executive assistant to Huggins.

▸ **Charles J. Deegan,** associate of Cummins and Brinkerhoff, Consulting Engineers, Fort Worth, Texas, has resigned and plans to establish his own consulting and advisory service.

▸ **W. C. Stevenson** was elected vice president in charge of industrial relations for Union Oil Company of California, Reese H. Taylor, president, announced. Stevenson formerly was assistant to the executive vice president, industrial relations.

Stevenson joined Union Oil in May, 1925, as a utilities inspector at Oleum refinery and progressed to superintendent of distillation in 1939. In 1940 he was transferred to the Los Angeles refinery in the same capacity and later made manager. He returned to Oleum as manager in December, 1942. In April, 1946, he was appointed assistant to the executive vice president.

W. C. Stevenson

Personals

▸ **K. W. Rugh** will become manager of the public relations department of Phillips Petroleum Company replacing **Chester W. Cleveland** who has resigned to re-establish his own public relations firm in Chicago.

It was also announced by K. S. Adams, chairman, and Paul Endacott, president, that **Fred Pralle** will become publicity director reporting directly to Rugh.

Rugh has been in the service of Phillips for more than 22 years, during the first 17 years having been engaged in the sales and distribution of liquefied petroleum gases, including manager of Philgas Company, a Phillips subsidiary. He has served as assistant manager sales department during the past five years.

▸ **J. M. Pattinson**, C. B. E. and **H. E. Snow**, C. B. E., were appointed managing directors of Anglo-Iranian Oil Company.

Pattinson, who was the company's general manager in Abadan throughout the last year, returned to the head office in London in 1945 and four years later was made a deputy director.

Snow has been connected with the Anglo-Iranian group since 1921 and, for the past 16 years, has been a member of the company's distribution department, of which he became deputy director in 1946.

Their appointments follow the resignations of **J. A. Jameson**, C. B. E. and **F. G. C. Morris**, who were appointed to the board in 1939 and 1946 respectively.

▸ **Curtis G. Condra**, Stanolind Oil and Gas Company, Fort Worth; **J. H. Dunn**, The Shamrock Oil and Gas Corporation, Amarillo; **H. B. Fuqua**, Texas Pacific Coal and Oil Company, Fort Worth; **R. G. McIntyre**, Standard Oil Company of Texas, Houston; and **W. A. Moncrief**, Fort Worth, were named by the Texas Mid-Continent Oil and Gas Association's executive vice president, Charles E. Simons, to serve on its advisory committee to the Interstate Oil Compact Commission. Texas is a member state of the Compact.

The Commission, made up of representatives from oil producing states devoted to the conservation of oil and gas, is holding its Summer meeting September 1-3 at Banff, Canada.

Dallas-Fort Worth Nomads at the last regular dinner meeting were: Mac Hiltpold, Buda Engine; George Stevens, Cummins Engine; Jack Mussler, Continental Supply; K. B. Winstead, Oil Well Supply; Cliff Athy, Ideco; Mike Hazel, Oil Well Supply.

Other Dallas-Fort Worth Nomads present were: Elmer Rubec, American Iron and Machine; Cliff Durley, Continental Supply; Jack Davis, Continental Supply; Bill Behrdorst, American Iron and Machine; F. R. (Colonel) House, Bethlehem Supply.

Taking on food are: Frank Millard, Schlumberger; Nick Tinker, independent producer from Old Mexico; H. C. Brand, Schlumberger; Ken Daggett, Welex Jet Services, Inc.; Abbott Sparks, *The Petroleum Engineer*; Glenn Tedford, Foster Cathead; Everett Cole, Emsco Derrick & Equipment Company.

Also at the Dallas-Fort Worth Nomads wingding are Glenn Tableman, WKM Company, center, who is clowning with some wizard-eyed specs while Joe Kelly, Reed Roller Bit Company, left, and Harry Stansbury, Atlantic Refining Company, grin at the spectacle.

99.8% Perfect

Amazing but true, over 99.8% of the thousands of Clark "Right Angle" Compressors built since 1936 are still operating today. This remarkable service record emphasizes a fact known to every "Right Angle" operator: Clark HRA Compressors have the stamina and ruggedness, the built-in quality to keep them on the job indefinitely. Their simplified 2-cycle, in-line design, together with precision construction, are responsible for extremely long life and low maintenance. If you require the ultimate in dependability, be sure to investigate the new high compression HRA. It features increased economy and even finer precision construction, combined with proven durability.

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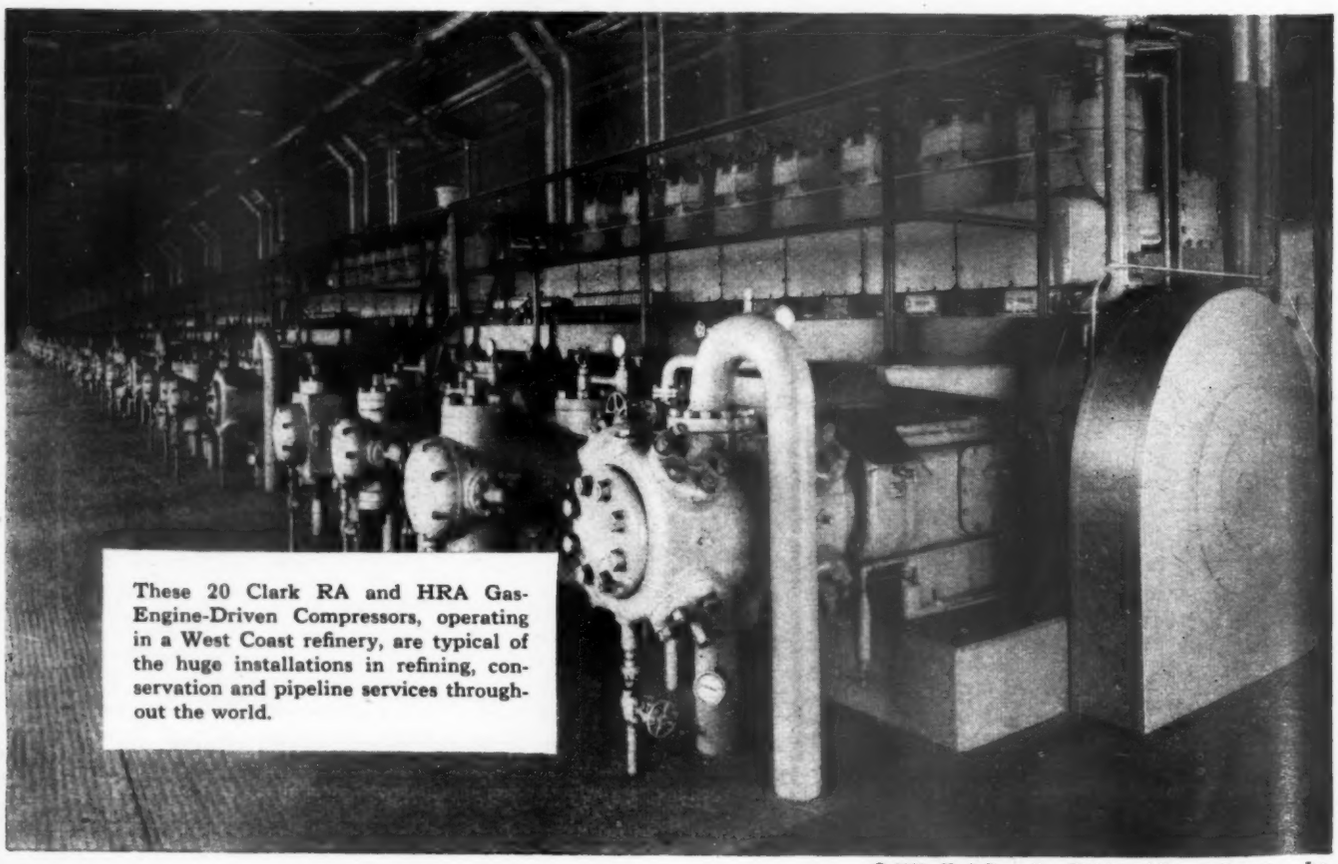

These 20 Clark RA and HRA Gas-Engine-Driven Compressors, operating in a West Coast refinery, are typical of the huge installations in refining, conservation and pipeline services throughout the world.

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Visiting with the Houston Nomads recently were: Mukti P. Mukherji, inspector of explosives, Department of Explosives, Government of India; A. J. Olsen, chief engineer, Continental Supply, Houston; Harold F. Browne, chief, Accident Prevention Branch, Bureau of Mines, speaker at a recent meeting of the group, and Don L. Carrell, petroleum consultant, La Paz, Bolivia.

Sydney A. Swensrud

Sydney A. Swensrud of Pittsburgh, Pennsylvania, president, Gulf Oil Corporation, will be chairman of a September drive in the petroleum industry to increase systematic savings in U. S. Defense Bonds among the nation's 500,000 oil workers. About 125,000 of them are now payroll savers; the campaign's goal is to sign up at least 125,000 more.

Complete cooperation in the drive has been pledged by the National Petroleum Council, headed by Walter S. Hallanan, president of the Plymouth Oil Company. Support of the drive has also been pledged by Frank M. Porter, president of the American Petroleum Institute.

Swensrud joined the Gulf Oil as executive vice president in May, 1947, becoming president a year later. He previously had been executive vice president of the Standard Oil Company of Ohio, which he joined in August, 1928, as assistant to the president. Swensrud received his Bachelor of Science degree at the University of Minnesota in 1923, and his master's degree at the Harvard Graduate School in 1927.

Harris Bateman, chief engineer, Cities Service Oil Company (Delaware), will soon join the Petroleum Administration for Defense in Washington as head of the materials sections, it was announced by S. B. Irelan, president. During his absence **C. S. Mitchell,** in addition to his duties as manager of crude oil supply and transportation, will be the executive in charge of the engineering division.

Ben D. (Tex) Leuty, Bartlesville, has been made assistant chief engineer.

A long-time Cities Service employee, Leuty joined the Cities Service junior engineer training school in 1924 after graduation from Texas A & M College with a BS degree in civil engineering. He took his permanent assignment in the engineering division, and later, was named chief civil engineer. In 1950 he was transferred to the crude oil supply and transportation division as special assistant to the manager, then named assistant manager of the division, in charge of affiliated pipelines. He will continue in this position.

H. J. (Jack) Readle has joined Husky Oil Company, Cody, Wyoming, as manager of purchasing and warehousing. Prior to becoming associated with Husky, Readle was regional purchasing agent for Phillips Petroleum Company at Houston, Texas. Readle received his schooling in Oklahoma and attended the Northeastern State Normal College at Tahlequah, Oklahoma. He was with Phillips for almost 30 years.

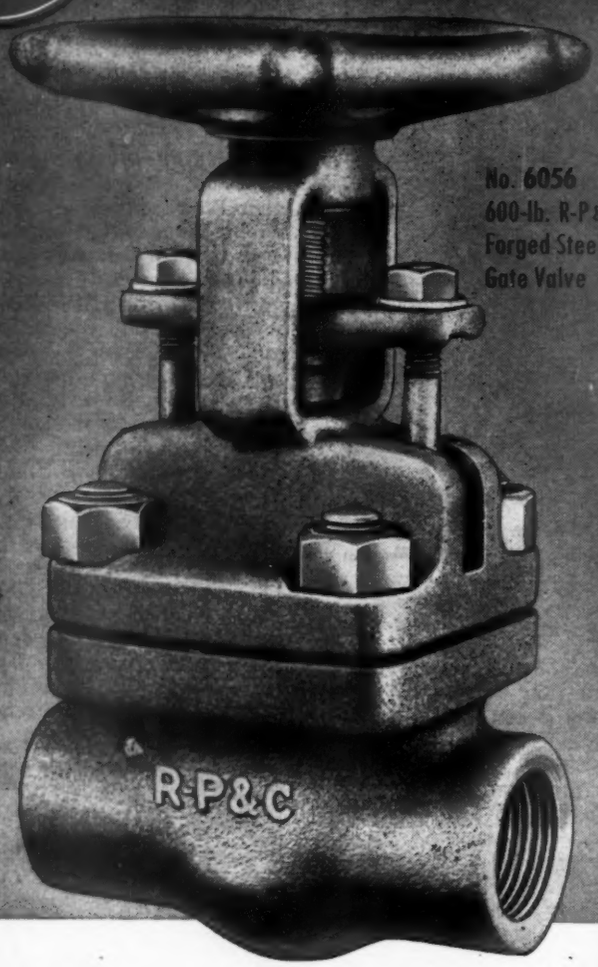
Herman C. Cowdery of Bartlesville, Oklahoma, has been named assistant purchasing agent for Cities Service Oil Company (Delaware). Cowdery received his education at Kansas State College, graduating with a degree of BS in civil engineering and an MS in applied mechanics. He did two years of research at the college before joining the Kansas State Highway Department. He was employed by Cities Service in 1937 as a member of its Engineering Department. After serving in several capacities with both Cities Service Oil and Cities Service Gas companies, he was transferred back to the oil company's engineering department in 1946 to direct the company's junior engineer training school.

L. H. Butterworth has been promoted to a new position as manager of operations, cost control, and personnel division of the manufacturing department of Standard Oil Company (Indiana) in the general office at Chicago, Illinois.

C. A. Cogan will succeed him as assistant general superintendent of the company's Casper, Wyoming, refinery. Cogan has been superintendent of the projects, capital expenditures, miscellaneous contracts sections in the manufacturing department.

Butterworth joined Standard in 1937 as a chemical engineer in the research department at Whiting, Indiana. In 1942 he was transferred to the manufacturing department as an assistant general foreman in the light oils division at the Whiting refinery, serving first in the light oils finishing department and later in the crude stills department. He was promoted to assistant general superintendent of the Casper refinery in 1947.

an ACCO product



Premium Quality Features

● Body, bonnet, yoke, wedge, and hand-wheel of this sturdy R-P&C Gate Valve are forged steel. Wedge is heat-treated. Seating surfaces are smoothly ground and chromium plated for near diamond hardness. Stainless steel swinging gland eyebolts and nuts won't corrode or freeze. Furnished in ¼" to 2" sizes. Screwed, flanged, or welded end.

It's a premium quality valve but NOT premium priced. See your R-P&C distributor or write nearest R-P&C district office.

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TRADE MARK

R-P&C valves

Simplified Radioactivity Survey Instrument

Portable, self-contained radioactivity survey instruments of the gamma type generally use a microammeter to indicate the radiation level. Ideally these survey instruments should be low in cost as well as compact and rugged. Yet microammeters are inherently neither cheap nor rugged, nor are they suited to mass production in extremely large volume. A new gamma survey instrument, recently developed by S. R. Gilford and S. Saito of the National Bureau of Standards electronic instrumentation laboratory, requires no microammeter.

In the NBS instrument, which was developed for the Navy Bureau of Ships, radiation levels are read directly from a potentiometer dial. To read an unknown value of radiation, the operator turns the dial to the point at which an

Fig. 1. Radioactivity survey instrument eliminates the rather expensive and fragile moving-pointer microammeter generally used to indicate radioactivity levels.

audio oscillation just begins. This point is determined aurally with the small earphone that is standard equipment for most survey instruments. This aural indication is particularly convenient for plotting contours of equal radioactivity; with the dial set for a particular radiation level, it is an easy matter for the operator to walk along and locate aurally a series of equally radioactive points.

Like many other gamma-radiation survey instruments, the NBS device uses a detector tube of the halogen-filled GM type, together with a vibrator high-voltage power supply operating from flashlight-type batteries. Output current of the detector is proportional to the incident radiation.

The heart of the aural indication method is a thyratron relaxation oscillator circuit. If the potential differences between the grid and cathode of the thyratron exceeds the firing potential, the circuit will oscillate. The unknown voltage derived from the detector tube current is applied to the outer terminals of the potentiometer, while the thyratron grid is connected to the moving contact. The potentiometer setting at the threshhold of oscillation thus depends on the radiation level, and the potentiometer dial can be calibrated directly in radiation units. ★ ★ ★

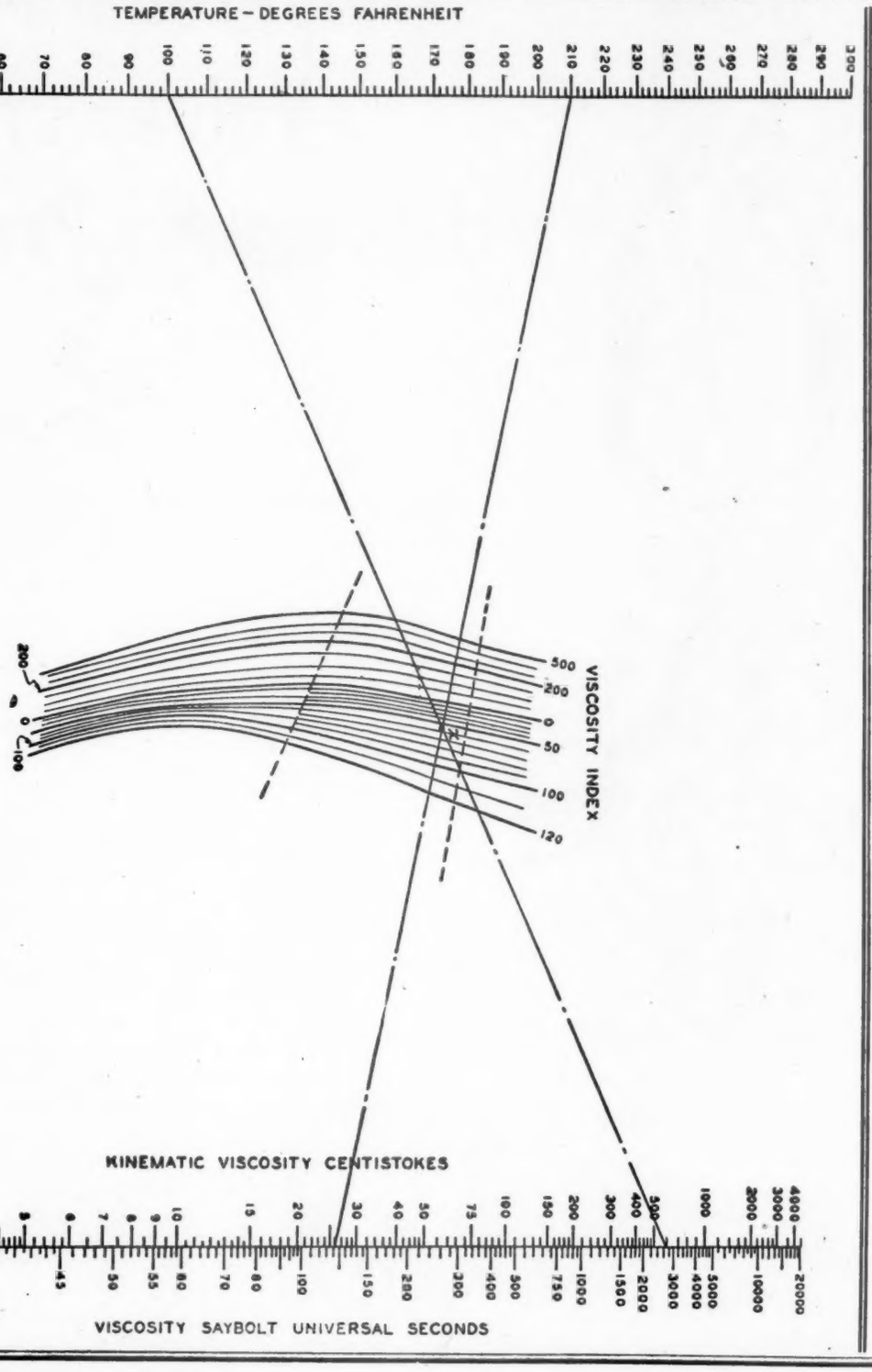
VISCOSITY INDEX CHART

The viscosity index chart was developed to extend the working range of the Dean and Davis viscosity index scale to heavier and lighter stocks than lubricating oils, and to provide a convenient means of viscosity index estimation from any two viscosity measurements within 40° to 300° F.

Example: The Saybolt Universal viscosities of an oil are 120 seconds at 210° F. and 2560 seconds at 100° F. A straight line is drawn between the 100° F. point on the left scale to the 2650 second point on the right scale. Similarly, the 210° F. point is connected by a straight line with 120 seconds. By interpolation between the curved lines in the center of the chart, the point of intersection X, of the drawn straight lines marks the viscosity index of the oil, approximately 55. The viscosity of this oil at any other temperature may be estimated by passing a straight edge through Point X, intercepting the viscosity scale at the viscosity corresponding to the intercept on the temperature scale.

Each curved line on the nomographic chart is the locus of index points corresponding to stocks of constant viscosity index. The portions of these lines bying between the two heavy broken lines were plotted directly from the data and formula of Dean and Davis. There is a slight disagreement between the viscosity indices in the chart and those of Dean and Davis stocks having viscosities between 40 and 45 seconds at 210° F. The curves from Dean and Davis did not join smoothly with the data on lighter stocks in this region. As a result, the viscosity indices of oils in this range are slightly higher when read from the chart than when calculated from the Dean and Davis equation.

Viscosity indices can be read from this chart with an accuracy proportioned to the experimental accuracy of the viscosity determinations. In the 60-120 viscosity index range, the estimation from the chart should agree with the Dean and Davis calculated value to within a difference of viscosity index of 5. The use of the Dean and Davis formula indicates an accuracy in the lower range of the viscosity index scale which is unwarranted by the experimental accuracy.



—Chart by courtesy Universal Oil Products Company.

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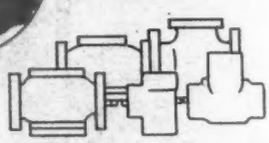
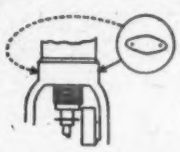
Diaphragm Motor Valves are Universally Preferred



FISHER ALLOY SPRINGS are tested for load tolerances of plus or minus 2½%.

VARIETY OF BODY TYPES and materials—iron, steel, bronze, alloys, single and double seated, angle and globe.



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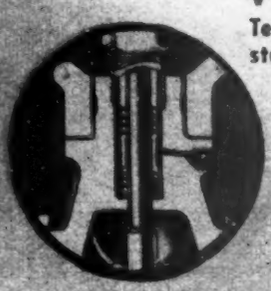
WIDE CHOICE OF INNER VALVES to provide desired flow characteristics.

QUALITY CONTROLLED materials and workmanship.

WALL SECTIONS conform with ASA fittings code.

Fisher offers the most versatile and complete line of Diaphragm Motor Valves—manufactured to handle pressure conditions up to 6,000 pounds. Available in metals for highly corrosive service and alloys for high temperature work. They are built for your specific requirements.



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Dual Teflon packing also available. 2 sets of packing separated with bleed area where purge zone is desired. Positively prevents outbound leakage—or inbound leakage under vacuum service. For dangerous toxic, corrosive, etc. applications.

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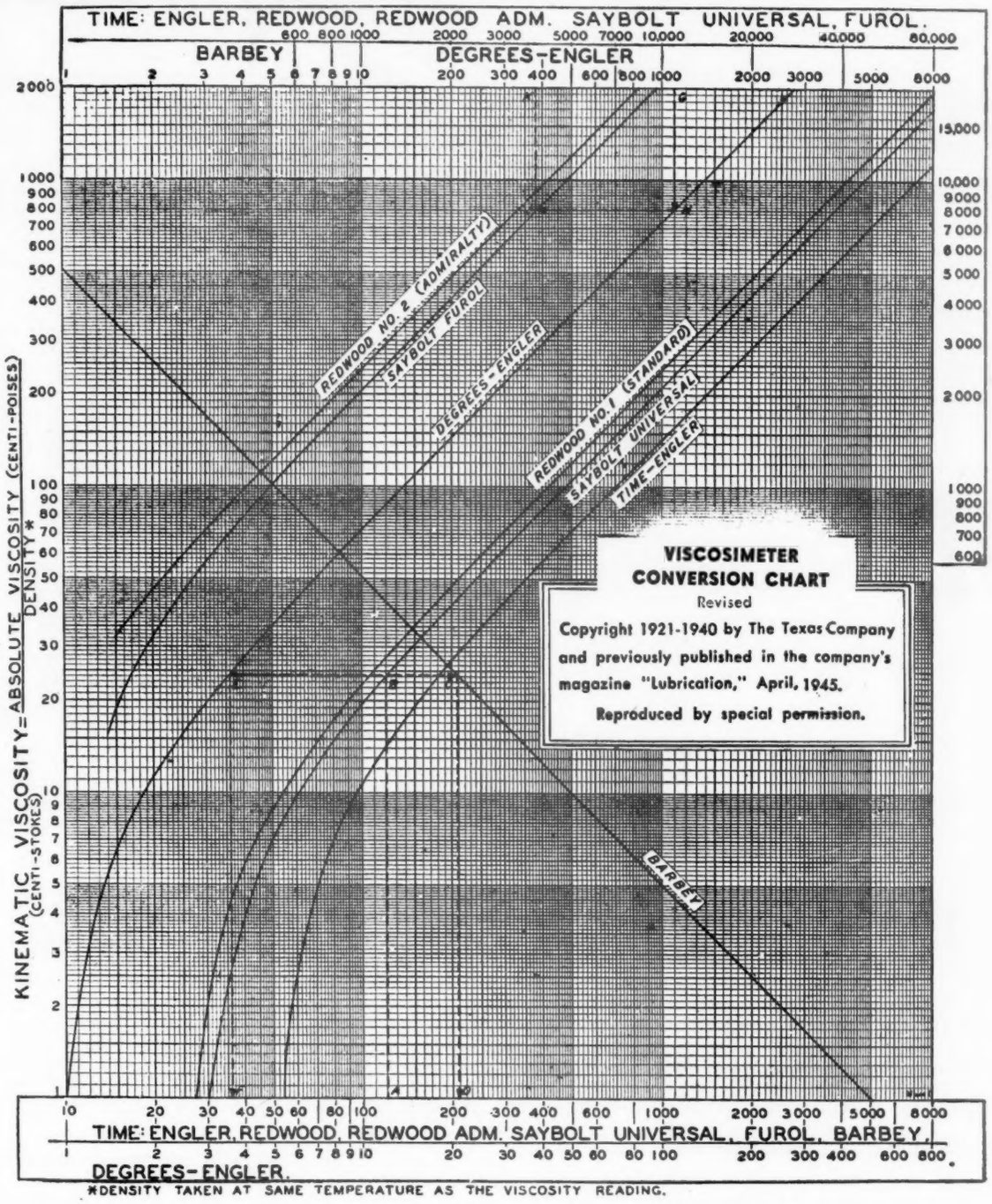
LEADS THE INDUSTRY IN RESEARCH FOR BETTER PRESSURE CONTROL

VISCOSIMETER CONVERSION CHART



*DENSITY TAKEN AT SAME TEMPERATURE AS THE VISCOSITY READING.

There are two sets of scales which must not be confused with each other. The scales at top and right-hand side go together, and apply only to very viscous products beyond the range of other scales.

The lower bottom scale applies only to Degrees-Engler. The upper bottom scale applies to all other readings, including Engler-Time.

In changing from one viscosimeter to another, scales at left and right are not used. Scales at top never used with those at bottom.

EXAMPLE: For ordinary cases.

GIVEN: Saybolt Universal Viscosity = 120".

DESIRED: Case (a) Barbey reading.
Case (b) Engler-Degree reading.

PROCEDURE: Find point on bottom scales for Saybolt Universal corresponding to 120" (A). Follow up vertically to curve marked Saybolt Universal (the known instrument) (B).

(a) To get Barbey reading: Follow horizontally to curve marked Barbey (C). Drop down to bottom scale for Barbey and read (D). Reading = 208°.

(b) To get Engler-Degree reading: Follow horizontally to curve marked Degrees-Engler (E). Drop down to lower of the two bottom scales, for Engler-Degrees and read (F). Reading = 3.60° i.e., 120" Saybolt = Barbey 208° = Engler 3.60.

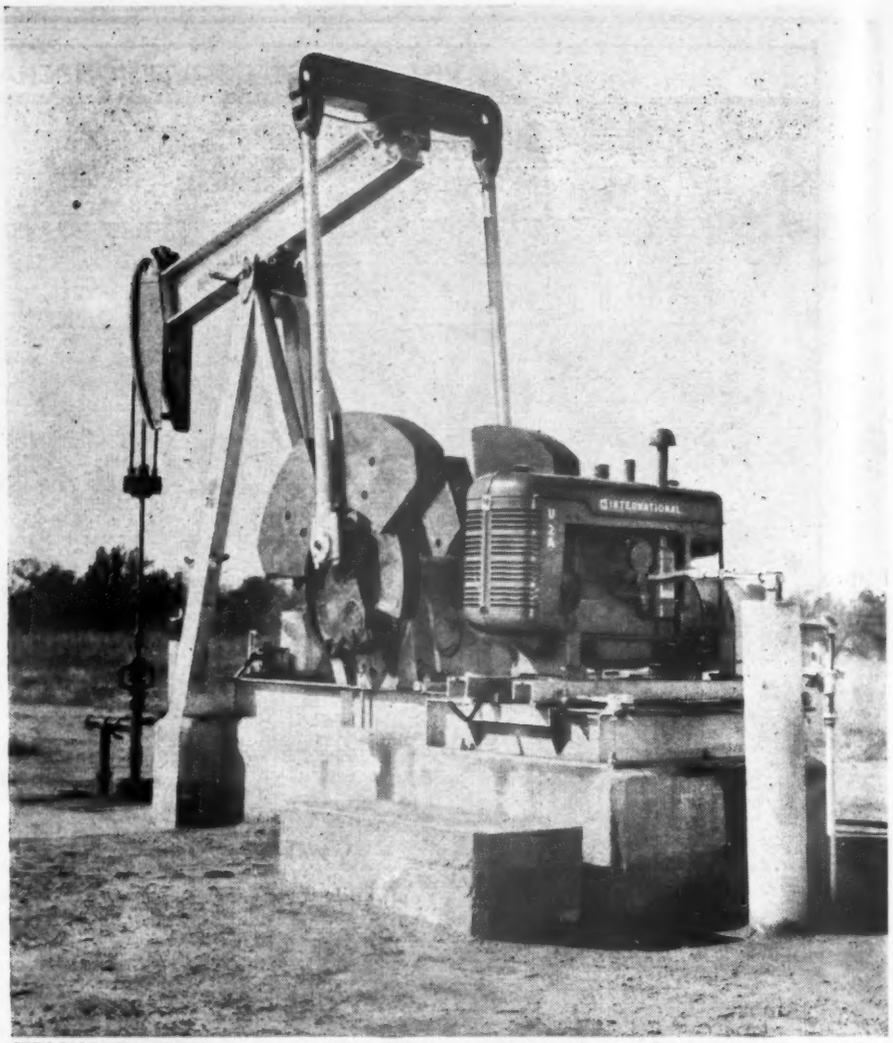
EXAMPLE: For very viscous fluids.

GIVEN: Engler-Degrees = 1100°.

DESIRED: Saybolt Furol reading.

PROCEDURE: Find point on upper scales under Degrees-Engler corresponding to 1100° (G). Follow vertically down to Degrees-Engler curve (H). Follow horizontally to curve marked Furol (J). Rise vertically to scales under Furol and read (K). Reading = 3800" i.e., 1100° Engler = 3800" Furol.

Pumps Fine for PINE



STEADY PUMP POWER on this 3,193-foot Oklahoma well comes from an International U-2A engine. Other natural gas-burning IH engines range from 13.6 to 49 horsepower.

100 Internationals Bring Up The Crude

Down Oklahoma way where oil wells are as common as cattle, oilman W. H. Pine of Okmulgee, operates more than 100 wells with International pumping engines.

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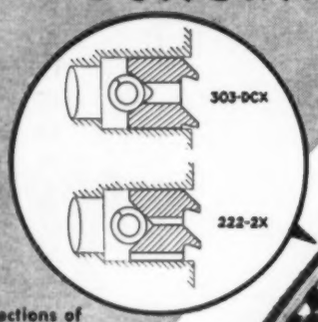
Saybolt universal seconds	Engler degrees	Absolute viscosity, centipoises,[1] also relative viscosity	Kinematic viscosity, poises per g. per cc, n/d	Redwood No. 1 seconds	Saybolt Furol seconds	Redwood admiralty seconds
32	1.08	1.41	0.0141			30
34	1.14	2.19	.0219			31
36	1.19	2.92	.0292			33
38	1.25	3.63	.0363			34
40	1.31	4.30	.0430			36
42	1.37	4.95	.0495			38
44	1.43	5.59	.0559			39
46	1.48	6.21	.0621			41
48	1.53	6.81	.0681			43
50	1.58	7.40	.0740			44
55	1.73	8.83	.0883			48
60	1.88	10.20	.1020			53
65	2.03	11.53	.1153			57
70	2.17	12.83	.1283			61
75	2.31	14.10	.1410			65
80	2.46	15.35	.1535			69
85	2.59	16.58	.1658			73
90	2.74	17.80	.1780			77
95	2.88	19.00	.1900			81
100	3.02	20.20	.2020	10	15	86
110	3.31	22.56	.2256	11	16	94
120	3.60	24.90	.2490	12	17	102
130	3.69	27.21	.2721	13	18	111
140	4.19	29.51	.2951	13	18	119
160	4.77	34.07	.3407	15	20	136
180	5.35	38.60	.3860	17	22	153
200	5.92	43.10	.4310	19	23	170
225	6.64	48.70	.4870	21	26	191
250	7.35	54.28	.5428	23	28	212
300	8.79	65.40	.6540	28	32	254
350	10.25	76.49	.7649	32	37	296
400	11.68	87.55	.8755	37	42	338
450	13.00	98.60	.9860	42	47	380
500	14.00	109.6	1.096	46	52	422
550	16.00	120.7	1.207	50	56	465
600	17.00	131.7	1.317	55	61	507
650	19.00	142.7	1.427	60	66	549
700	20.00	153.7	1.537	64	71	591
800	23.00	175.8	1.758	74	81	676
900	26.00	197.8	1.978	83	91	760
1000	29.00	219.8	2.198	92	101	845
1500	43.00	329.9	3.299	138	150	1267
2000	58.00	439.9	4.399	184	200	1690
2500	72.00	549.9	5.499	230	250	2112
3000	87.00	659.9	6.599	276	300	2535
3500	101.00	769.9	7.699	322	350	2957

[1]Values in this column must be multiplied by the specific gravity of the fluid at the temperature of the measurement to complete the conversion

Why COOK "SUPER-FLEX" OIL CONTROL RINGS reduce lube-oil consumption



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FLOW OF OIL THROUGH PIPE LINES

Those who occasionally have to make computations relating to the flow of fluids through pipe lines may well be confused by the numerous formulas in use, and particularly by the variation in the systems of units employed. The following information has been compiled for the purpose of establishing a simple, fixed procedure. It is recommended, nevertheless, that the calculators shall review the literature on pipeline flow, as it is thought that in this way they will gain confidence in the modified Chezy formula recommended below.

EXPLANATION OF SYMBOLS

B = barrels (42 gal.)
d = inside diameter of pipe (in.)
d_o = outside diameter of pipe (in.)
D = inside diameter of pipe (ft.)
f = friction factor
f_1 = fiber stress—lb. per sq. in.
h = loss of head in feet of fluid pumped
P = friction loss, lb. per 1000 ft.
P_1 = pressure—lb. per sq. in.
p = density lb. per cu. ft. (Water=62.4283 lb.)
Q = rate of flow barrels (42 gal.) per hr.
R = Reynolds number
s = specific gravity (Water = 1)
t = Saybolt seconds
t_1 = pipe wall, in.
u = absolute viscosity (lb., ft., sec.)
v = velosity, ft. per sec.
W = weight, tons per mile
w = weight, lb. per ft.
z = aboslute viscosity (centipoise)

To convert viscosity, usually reported in U.S.A. in Saybolt seconds, to absolute viscosity in centipoises (z) use the following: $z = s\left(0.22t - \frac{180}{t}\right)$. If viscosity is given in English Units (u), convert as follows: $z = 1488.16u$.

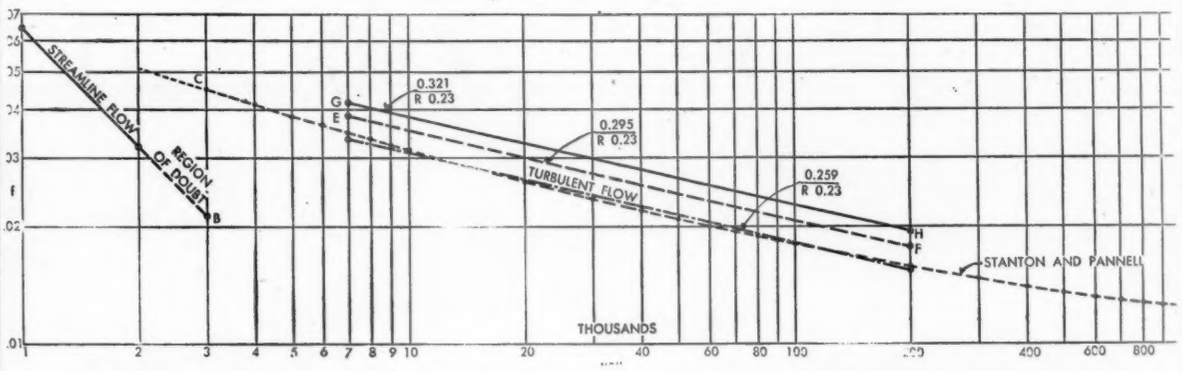
To convert gravity reported in API degrees to specific gravity (s) use the following: $s(60°F./60°F.) = \frac{141.5}{131.5 + °API}$

Formula:

$$P = \frac{6.61\,fQ^2s}{d^5}\ (1) \quad \text{or} \quad Q = \left(\frac{Pd^5}{6.61fs}\right)^{1/2}\ (2) \quad \text{or} \quad d = \left(\frac{6.61\,fQ^2s}{P}\right)^{1/5}\ (3) \quad \text{or} \quad f = \frac{Pd^5}{6.61Q^2s}\ (4)$$

The above variants of the Chezy formula, as written by Darcy, account for all mechanical quantities involved excepting the variation in roughness of the pipe wall. Successful application of the formula depends, therefore, on the selection of a proper friction factor (f) and values for "f" for various Reynolds numbers (Dvp/u = 2213.5Qs/dz) may be obtained from the following graph:

f vs. R GRAPH



The straight line AB is used for streamline flow or when "R" does not exceed 2,000, its equation is fR = 64. The curve CD is Stanton and Pannell's values of "f" for small, smooth pipe and is used for turbulent flow in new steel pipe 6 in. and larger in diameter when "R" is 3,000 or more. The interval between R 2,000 and R 3,000 is unstable and the flow may be either streamline or turbulent, so for this range, turbulent value, for "f" should be used. For turbulent flow in new steel pipe, smaller than 6 in. diameter, "f" values will exist higher on the scale than CD and these are shown on the graph at EF for 2½ in. to 4 in. new steel pipe and at GH for 1½ in. and 2 in. new steel pipe.

It will be noted from the foregoing, however, that when rate of flow (Q) is desired for a given pressure drop (P) in a given line, the application of the graph above involves a trial and error procedure that makes its use unattractive. To eliminate this procedure it is known to be sufficiently accurate, when "R" is between 7,000 and 200,000, to write for 1½ in. and 2-in. new steel pipe that $f = 0.321/R^{0.23}$, for 2½-in. to 4-in. new steel pipe that $f = 0.295/R^{0.23}$ and for 6-in. to 12-in. new steel pipe that $f = 0.259/R^{0.23}$. By substituting these values of "f" in the formulas (1), (2) and (3) we can write the following formulas:

TURBULENT FLOW	1½ in. and 2 in.	$P = \frac{0.361\,Q^{1.77}\,s^{0.77}\,z^{0.23}}{d^{4.77}}$	$Q = \left(\frac{Pd^{4.77}}{0.361\,s^{0.77}\,z^{0.23}}\right)^{\frac{1}{1.77}}$	$d = \left(\frac{0.361\,s^{0.77}\,z^{0.23}\,Q^{1.77}}{P}\right)^{\frac{1}{4.77}}$
	2½ in. to 4 in.	$P = \frac{0.331\,Q^{1.77}\,s^{0.77}\,z^{0.23}}{d^{4.77}}$	$Q = \left(\frac{Pd^{4.77}}{0.331\,s^{0.77}\,z^{0.23}}\right)^{\frac{1}{1.77}}$	$d = \left(\frac{0.331\,s^{0.77}\,z^{0.23}\,Q^{1.77}}{P}\right)^{\frac{1}{4.77}}$
	6 in. to 12 in.	$P = \frac{0.291\,Q^{1.77}\,s^{0.77}\,z^{0.23}}{d^{4.77}}$	$Q = \left(\frac{Pd^{4.77}}{0.291\,s^{0.77}\,z^{0.23}}\right)^{\frac{1}{1.77}}$	$d = \left(\frac{0.291\,s^{0.77}\,z^{0.23}\,Q^{1.77}}{P}\right)^{\frac{1}{4.77}}$

For STREAMLINE Flow

All sizes	$P = 0.1911\,\frac{Qz}{d^4}$	$Q = \left(\frac{Pd^4}{0.1911z}\right)$	$d = \left(\frac{0.1911\,Qz}{P}\right)^{1/4}$

USEFUL FORMULAS

Velocity $v = 0.2859\,Q/d^2$ or $Q = d^2\,v/.2859$ or $d = (0.2859\,Q/v)^{1/2}$

Barlow $P = 2\,t_1\,f_1/d_o$ or $f_1 = d_oP\,/2t_1$
Pipe Weight $W = 28.2\,(d_o - t_1)\,t_1$
Pipe Weight $w = 10.68\,(d_o - t_1)\,t_1$
Pipe contents 1000′ B $= 0.9714\,d^2$
Pipe contents mile B $= 5.1291\,d^2$
Rate of flow GPM $= 0.7Q$

—Courtesy Frank E. Richardson

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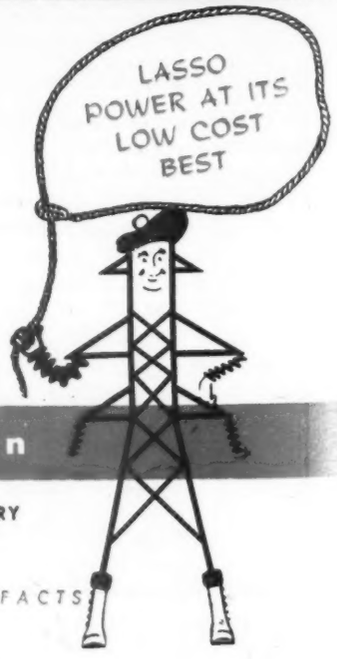

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FLOW OF GAS THROUGH PIPE LINES

WEYMOUTH FORMULA: $$Q_s = 433.45 \frac{T_s}{P_s} \times d^{2.667} \times \left(\frac{P_1^2 - P_2^2}{LST}\right)^{1/2} \quad \ldots\ldots\ldots \text{(a)}$$

LEGEND

Q_s = rate of gas flow, cu. ft. per 24 hr measured at Standard conditions
d = internal diameter of pipe, inches
P_1 = initial pressure lb. per sq. in. abs.
P_2 = terminal pressure lb. per sq. in. abs.
L = length of line, miles
S = specific gravity flowing gas (air = 1)
T = absolute temp. flowing gas (°F. + 460)
T_s = standard absolute temp. (°F. + 460)
P_s = standard pressure lb. per sq. in. abs.

Using values $S = .60$, $T_s = 520°$, $T = 520°$ and $P_s = 14.65\#$ formula is $$Q_s = 871 \times d^{2.667} \times \left(\frac{P_1^2 - P_2^2}{L}\right)^{1/2} \quad \text{(b)}$$

Values of $d^{2.667}$ are given in Fig 1 and remainder of formula can be solved by use of squares and square roots; however if S, T and P_s are different than .60, 60°F. and 14.65 (14.4 + 4 oz.) multiply Q_s of formula (b) by factors shown in Figs. 2, 3 and 4.

Weymouth Formula agrees more closely with metered rates than those calculated by any other formula, however the degree of error increases with pressure. Late experimenters have found that if the calculations made from Weymouth Formula are increased by the compressibility factor of the gas that the figure will practically coincide with the metered flow. Fig. 5 shows compressibility factor of a gas most commonly found in gas lines and can be used safely if exact data is not available on the gas to be transported. The average pressure in the line can be figured by the formula:

$$\text{Average} = \tfrac{2}{3}\left(P_1 + P_2 - \frac{P_1 P_2}{P_1 + P_2}\right)$$

FIG. 1

Values of $d^{2.667}$ for use in $Q_s \times 871 \times d^{2.667} \times \left(\frac{P_1 - P_2}{L}\right)^{1/2}$

d	$d^{2.667}$	d	$d^{2.667}$	d	$d^{2.667}$	d	$d^{2.667}$	d	$d^{2.667}$
2.0	6.3	4.2	45.9	6.6	153.3	8.941	344 6	11.3	648.0
2.067	6.9	4.3	48.9	6.7	159.5	9.0	350.5	11.4	658.8
2.1	7.2	4.4	52.0	6.8	166.0	9.1	361.0	11.5	673.8
2.2	8.2	4.5	55.2	6.9	172.6	9.2	371.6	11.6	689.5
2.3	9.2	4.6	58.5	7.0	179.3	9.3	382.5	11.7	705.5
2.4	10.3	4.7	62.0	7.1	186.2	9.4	393.6	11.8	721.7
2.5	11 5	4.8	65.6	7.2	193.3	9.5	404.8	11 9	738.1
2.6	12.8	4.9	69.3	7.3	200.5	9.6	416.3	12.000	754.8
2.7	14.1	5.0	73.1	7.4	207.9	9.7	428.0	12.1	771.7
2.8	15.6	5.1	77.1	7.5	215.5	9.8	439.8	12.2	788.8
2.9	17.1	5.2	81.2	7.6	223.3	9.9	451.9	12.3	806.1
3.0	18.7	5.3	85.4	7.7	231.2	10.0	464.2	12.4	823.7
3.068	19.9	5.4	89.8	7.8	239 3	10.020	467.0	12.5	841.6
3.1	20.4	5.5	94.3	7.9	247.6	10.1	476.6	12.6	859.7
3.2	22.2	5.6	98.9	7.981	254.5	10.2	489.3	12.7	878.0
3.3	24.1	5.7	103 7	8.0	256.0	10.3	502.2	12.8	896.5
3.4	26.1	5.8	108.6	8.1	264.6	10.4	515.3	12.9	915.3
3.5	28.2	5.9	113.7	8.2	273 4	10.5	528.7	13.0	934.4
3.6	30.4	6.0	118.9	8.3	282.4	10.6	542.2	13.1	953.7
3.7	32.7	6.065	*122.4	8.4	291.6	10.7	555.9	13.2	973.2
3.8	35.2	6.1	124.2	8.5	300.9	10.8	569.9	13.250	983.9
3.9	37.7	6.2	129.9	8.6	310.5	10.9	584.1	13.3	993.0
4.0	40.3	6.3	135.4	8.7	320.2	11.000	598.5	13.4	1013
4.026	41.0	6.4	141.2	8.8	330.1	11 1	613.1	13.5	1033
4.1	43.1	6.5	147.1	8.9	340.2	11.2	627.9	13.6	1054

FIG. 2

Factors to adjust for specific gravity (s)

S	Factor	S	Factor
50	1.095	60	1.000
51	1.085	61	.992
52	1.074	62	.983
53	1.064	63	.976
54	1.054	64	.968
55	1.045	65	.961
56	1.035	66	.953
57	1.026	67	.946
58	1.017	68	.939
59	1.008	69	.933

FIG. 3

Factors to change from flowing temperatures of 60°F. to actual flowing temperatures.

°F.	Factor	°F.	Factor	°F.	Factor	°F.	Factor
50	1.0098	60	1.0000	70	.9905	80	.9813
51	1.0088	61	.9990	71	.9896	81	.9804
52	1.0078	62	.9981	72	.9887	82	.9795
53	1.0068	63	.9971	73	.9877	83	.9786
54	1.0058	64	.9962	74	.9868	84	.9777
55	1.0048	65	.9952	75	.9859	85	.9768
56	1.0039	66	.9943	76	.9850	86	.9759
57	1.0029	67	.9933	77	.9840	87	.9750
58	1 0019	68	.9924	78	.9831	88	.9741
59	1.0010	69	.9915	79	.9822	89	.9732

FIG. 4

Factors to change from pressure base of 14.4 lb. + 4 oz. to some other pressure base

New base	abs. lb.	factor	New base	abs. lb.	factor
14.4 + 4 oz.	= 14.650	= 1.000	14.7 + 2 oz.	= 14.825	= .988
30" Hg abs.	= 14.730	= .995	14.7 + 4 oz.	= 14.950	= .980
14.4 + 8 oz.	= 14.900	= .983	14.7 + 10 oz.	= 15.325	= .956
14.4 + 10 oz.	= 15.025	= .975	14.7 + 2 lb.	= 16.700	= .877

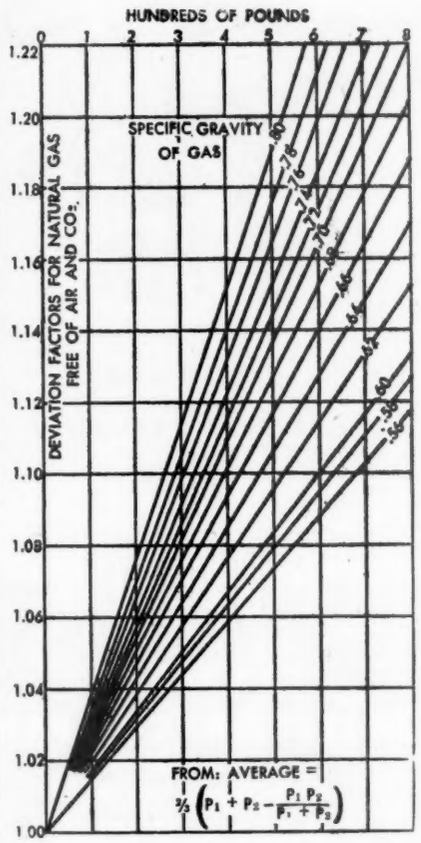
PROBLEM: Calculate the capacity of a 6.06" I.D. gas pipe line 7 miles long, inlet and outlet pressures 800 and 400# absolute, respectively, specific gravity .63, flowing temperature 68°F., pressure base 14.4 + 10 oz.

Using Formula (b), we have: $871 \times 122.4 \times 261.9$, or 27,921,264 cu. ft.

Corrected for specific gravity (.63), flowing temperature (68°F.), pressure base (14.4 + 10 oz.), and compressibility, we have:

$27{,}921{,}264 \times .976 \times .9924 \times .975 \times 1.122$, or 29,584,833 cu. ft.

FIG. 5



—*Courtesy Frank E. Richardson of Foreman-Richardson-Baird*

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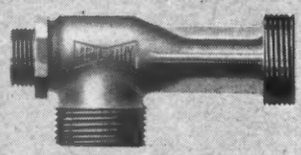

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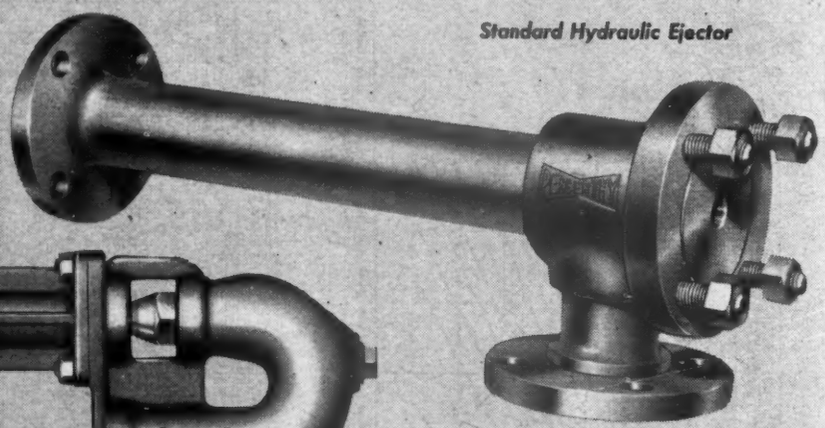

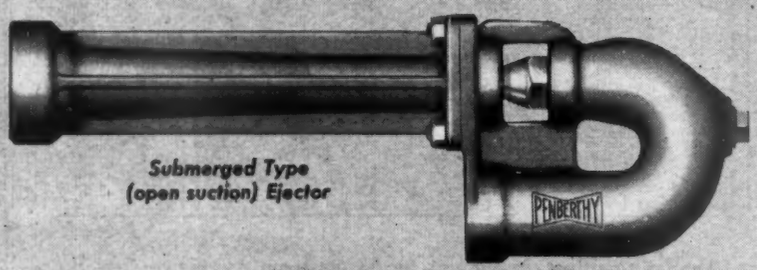

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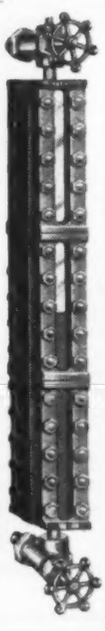

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Established 1886

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GAS-OIL RATIO CONVERSION TABLE

Gas-oil ratio (cu. ft./bbl.)	Yield (bbl./MMCF)	Content (gal./MCF)	Gas-oil ratio (cu. ft./bbl.)	Yield (bbl./MMCF)	Content (gal./MCF)
1 0	1,000,000 00	42,000.000	450.0	2,222.22	93.333
10 0	100,000.00	4,200.000	460.0	2,173.91	91 304
20 0	50,000.00	2,100.000	470.0	2,127.66	89 362
30 0	33,333 33	1,400.000	480.0	2,083.33	87.500
40 0	25,000.00	1,050.000	490.0	2 040.82	85.714
50.0	20,000.00	840.000	500.0	2,000.00	84.000
60 0	16,666.67	700.000	510.0	1,960.78	82.353
70 0	14,285.71	600.000	520.0	1,923.08	80 769
80 0	12,500.00	525.000	530.0	1,886.79	79 245
90 0	11,111.11	466.667	540.0	1,851 85	77 777
100.0	10,000.00	420.000	550.0	1,818.18	76.364
110 0	9,090.00	381 818	560 0	1,785.71	75.000
120.0	8,333 33	350 000	570 0	1,754.39	73.684
130 0	7,692.31	323 076	580.0	1,724.14	72 414
140 0	7,142.86	300.000	590 0	1,694.92	71 186
150.0	6,666.67	280.000	600.0	1,666.67	70 000
160.0	6,250.00	262.500	610 0	1,639.34	68 852
170 0	5,882.35	247.059	620 0	1,612.90	67 742
180 0	5,555 56	233 333	630.0	1.587.30	66 667
190.0	5,263 16	221 053	640.0	1 562.50	65.625
200 0	5,000.00	210.000	650 0	1,538 46	64.615
210 0	4,761.90	200 000	660.0	1,515 15	63 636
220 0	4,545.46	190.909	670 0	1,492.54	62.687
230 0	4,347 83	182 609	680.0	1,470.59	61.765
240 0	4,166.67	175.000	690.0	1,449.28	60.870
250 0	4,000.00	168.000	700.0	1,428.57	60.000
260 0	3,846.15	161.538	710.0	1,408 45	59 155
270 0	3,703.71	155 555	720 0	1,388 89	58.333
280 0	3,571.43	150.000	730 0	1,369.86	57 534
290.0	3,448 28	144.828	740.0	1,351.35	56.757
300 0	3,333.33	140.000	750.0	1,333.33	56 000
310 0	3,225 81	135 484	760 0	1,315.79	55 263
320.0	3,125.00	131.250	770.0	1,298.70	54.545
330.0	3,030.30	127 273	780.0	1,282 05	53.846
340.0	2,941.18	123.529	790.0	1,265.82	53.165
350 0	2,857.14	120.000	800.0	1,250.00	52.500
360.0	2,777 78	116 667	810.0	1,234.57	51.852
370.0	2,702.70	113.514	820 0	1,219.51	51 220
380.0	2,631 58	110 526	830 0	1.204 82	50 602
390 0	2.564.10	107 692	840.0	1,190.48	50.000
400.0	2,500.00	105 000	850 0	1,176.47	49.412
410.0	2 439.02	102.439	860 0	1,162.79	48.837
420 0	2,380 95	100 000	870.0	1,149.43	48.276
430.0	2.325.58	97 674	880.0	1,136.36	47.727
440.0	2,272.73	95.455	890 0	1,123.60	47.191

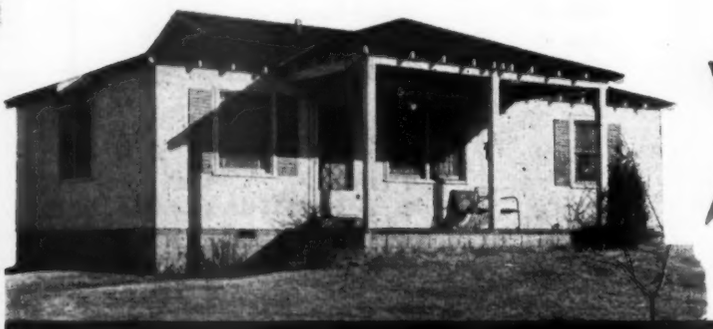
Example: 400 cu. ft./bbl.=2,500.00 bbl./million cu. ft.=105.000 gal./thousand cu. ft.

Look for this identification on

WHITMOR field homes—

it's Your Guarantee of Quality

On every distinctive Whitmor field home you will find a little metal identification — it's our way of saying that we are proud of that home — Proud enough to put our name on it. Behind it there are over 31 years of homebuilding experience — experience that means the difference between homes — or just housing! The Whitmor Home has been designed for employee comfort and company prestige . . . Many large oil companies have already seen the increase of employee efficiency and satisfaction. Yes, a Whitmor home is an investment in a sure thing "employee satisfaction" — this means that you are not just training employees for another company. . . . You demand the best employee — give him a home that he can be proud of! Give him a Whitmor distinctive field home.



"The Finest in the Field"

WHITMOR

homebuilders Inc.

5525 East 15th. Street • Tulsa, Oklahoma
Box 5037 • Phone 6-1137

You demand the best employees — They deserve the best homes

GAS-OIL RATIO CONVERSION TABLE

Gas-oil ratio (cu. ft./bbl.)	Yield (bbl./MMCF)	Content (gal./MCF)	Gas-oil ratio (cu ft./bbl.)	Yield (bbl./MMCF)	Content (gal./MCF)
900	1,111.11	46.667	1500	666.67	28.000
910	1,098.90	46 154	1520	657.89	27 632
920	1,086 96	45.652	1540	649 35	27 273
930	1,075.27	45 161	1560	641 03	26 923
940	1,063.83	44.681	1580	632.91	26 582
950	1,052 63	44 210	1600	625 00	26.250
960	1,041.67	43 750	1620	617 28	25.926
970	1,030 93	43.299	1640	609.76	25 610
980	1,020.41	42.857	1660	602.41	25 301
990	1,010.10	42.424	1680	595.24	25.000
1000	1,000.00	42.000	1700	588.24	24.706
1010	990.09	41 584	1720	581.40	24 419
1020	980.39	41 176	1740	574.71	24 138
1030	970.87	40 777	1760	568 18	23.864
1040	961.54	40.385	1780	561.80	23.596
1050	952.38	40 000	1800	555.56	23 333
1060	943.40	39 623	1820	549 45	23 077
1070	934 58	39 252	1840	543 48	22 826
1080	925 93	38.888	1860	537 63	22.581
1090	917.43	38 532	1880	531.91	22 340
1100	909.09	38 182	1900	526.32	22 105
1110	900.90	37.838	1920	520 83	21 875
1120	892.86	37 500	1940	515 46	21 649
1130	884 96	37 168	1960	510 20	21 429
1140	877.19	36 842	1980	505 05	21 212
1150	869 57	36.522	2000	500.00	21 000
1160	862.07	36 207	2025	493 83	20 741
1170	854 70	35 897	2050	487 80	20 488
1180	847 46	35.593	2075	481 93	20 241
1190	840.34	35 294	2100	476 19	20 000
1200	833.33	35 000	2125	470 59	19 765
1220	819 67	34.426	2150	465.12	19.535
1240	806 45	33 871	2175	459 77	19.310
1260	793.65	33.333	2200	454.55	19.091
1280	781.25	32.813	2225	449.44	18.876
1300	769.23	32.308	2250	444.44	18.667
1320	757 57	31 818	2275	439 56	18.462
1340	746.27	31.343	2300	434 78	18.261
1360	735 29	30 882	2325	430.11	18 065
1380	724.64	30.435	2350	425.53	17.872
1400	714 29	30 000	2375	421.05	17 684
1420	704.23	29 577	2400	416.67	17 500
1440	694.44	29.167	2425	412.37	17.320
1460	684.93	28.767	2450	408.16	17 143
1480	675.68	28 378	2475	404.04	16.970

Example: 1200 cu. ft./bbl.=833.33 bbl./million cu. ft.=35.000 gal./thousand cu. ft.

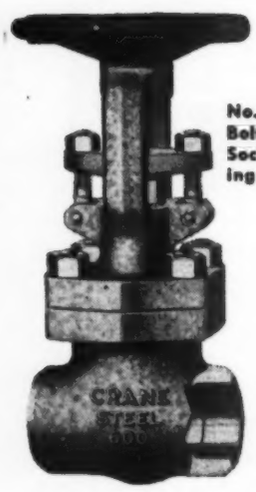
why CRANE 600-pound small steel gates are sure to meet your needs

You can't top these Crane Small Steel Gates for dependable performance on high pressure, high temperature lines . . . for ease of operation . . . for simplified maintenance. That's because they include design features normally found only in larger or more expensive valves.

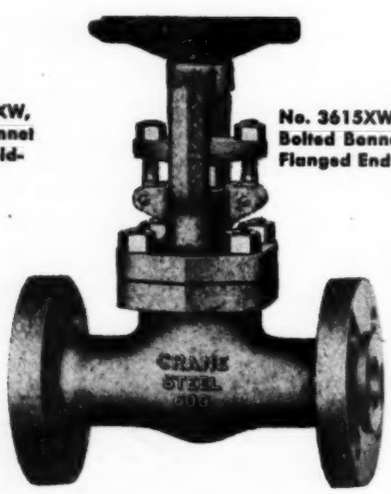
Then too, these Crane valves are available in a choice of types to meet your particular requirements. For example, with union or bolted bonnets; with screwed, flanged, or socket-welding ends; and in trim materials recommended for all common fluids.

GET NEW DESCRIPTIVE CIRCULAR AD-1881

For complete information—including prices—about these longer lasting, easier operating Crane Small Steel Gate Valves. Ask your Crane Representative for your copy, or write direct. No obligation.



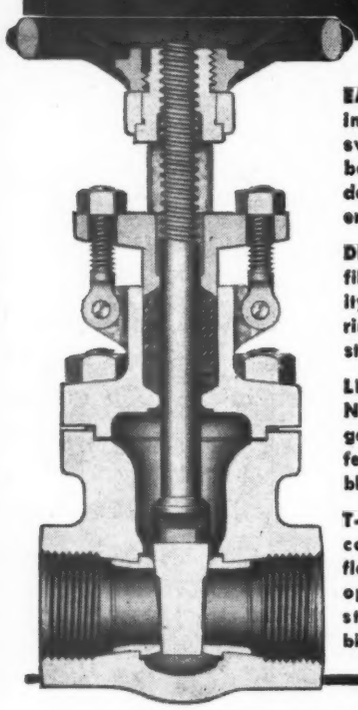
No. 3611XW, Bolted Bonnet Socket-Welding Ends



No. 3615XW, Bolted Bonnet Flanged Ends

UNION BONNET GATE. Screwed ends. Sizes: ¼ to 2-inch. Available in three different trim materials for a wide range of services. Also with socket welding ends

Easy to Operate... Easy to Service



EASY ACCESS to stuffing box assured by swinging gland eyebolts. Improved yoke design provides liberal working space.

DEEP STUFFING BOX filled with high quality asbestos packing rings maintains tight stem seal.

LEAKPROOF BONNET JOINT. Soft iron gasket in male and female joint cannot blow out.

T-HEAD DISC-STEM connection provides flexibility for smooth operation; prevents stem distortion or binding of parts.

Cross-section No. 3607XW, Bolted Bonnet Gate, Screwed

CRANE CO.

General Offices:
836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

GAS-OIL RATIO CONVERSION TABLE

Gas-oil ratio (cu. ft./bbl.)	Yield (bbl./MMCF)	Content (gal./MCF)	Gas-oil ratio (cu ft./bbl.)	Yield (bbl /MMCF)	Content (gal /MCF)
2500	400.00	16.800	3625	275.86	11.586
2525	396.04	16 634	3650	273.97	11 507
2550	392.16	16.471	3675	272.11	11 429
2575	388.35	16.311	3700	270.27	11.351
2600	384 62	16.154	3725	268 46	11.275
2625	380.95	16.000	3750	266.67	11 200
2650	377.36	15.849	3775	264.90	11.126
2675	373.83	15.701	3800	263 16	11.053
2700	370.37	15.556	3825	261.44	10 980
2725	366.97	15.413	3850	259.74	10 909
2750	363.64	15.273	3875	258.06	10.839
2775	360.36	15.135	3900	256.41	10.769
2800	357.14	15.000	3925	254.77	10.701
2825	353 98	14.867	3950	253.16	10 633
2850	350.88	14.737	3975	251.57	10 566
2875	347.83	14.609	4000	250.00	10.500
2900	344.83	14.483	4050	246 91	10.370
2925	341.88	14.359	4100	243 90	10.244
2950	338.98	14.237	4150	240.96	10.120
2975	336.13	14.118	4200	238.10	10.000
3000	333.33	14.000	4250	235.29	9 882
3025	330.58	13 884	4300	232 56	9.767
3050	327.87	13.770	4350	229 89	9 655
3075	325.20	13.659	4400	227 27	9.546
3100	322.58	13.548	4450	224.72	9.438
3125	320 00	13.440	4500	222.22	9.333
3150	317.46	13.333	4550	219.78	9.231
3175	314 96	13 228	4600	217.39	9.130
3200	312 50	13.125	4650	215.05	9.032
3225	310.08	13.023	4700	212.77	8 936
3250	307.69	12 923	4750	210.53	8.842
3275	305.34	12.824	4800	208 33	8 750
3300	303.03	12.727	4850	206.16	8.660
3325	300 75	12 632	4900	204 08	8.571
3350	298.51	12.537	4950	202.02	8.485
3375	296.30	12 444	5000	200.00	8.400
3400	294.12	12.353	5050	198.02	8.317
3425	291.97	12 263	5100	196.08	8 235
3450	289.86	12.174	5150	194.17	8 155
3475	287.77	12.086	5200	192.31	8.077
3500	285.71	12.000	5250	190.48	8.000
3525	283.69	11.915	5300	188.68	7.925
3550	281.69	11.831	5350	186.92	7.850
3575	279.72	11.748	5400	185.19	7.778
3600	277 78	11.667	5450	183.49	7.706

Example: 4000 cu. ft./bbl.=250.00 bbl./million cu. ft.=10.500 gal./thousand cu. ft.

LAUGH with BARNEY

Then there's the Sultan who kept his harem three miles from where he lived. Every day he sent his man servant to get him a girl. The Sultan lived to be eighty-seven, but the servant died when he was only thirty.

The moral of this story is: It's not the women that kill you, but the running after them.

* * *

They say he married her because her uncle left her a million dollars. But he claims he would have married her no matter who had left it to her.

* * *

Wife: "I was a fool when I married you."

Any of us: "I guess you were, but I was so infatuated that I didn't notice it then."

* * *

A Pasadena, California, man, arrested for driving 63 miles an hour while eating grapes with one hand, explained: "I was hungry."

* * *

Here is a fact
That is unmistakable;
The second baby
Doesn't seem so breakable.

* * *

Have you heard the new radio program . . . the girl who wanted two bathrooms, or . . . John's Wife's Other John?

"But, dear," moaned the husband, "you promised me you wouldn't buy a new dress. Remember?"

"I know," replied the modern Eve, "the devil tempted me."

"Why didn't you say, 'Get thee behind me, Satan?'" inquired the poor man.

"I did," she answered sweetly, "but he whispered over my shoulder, 'It looks just beautiful in the rear'."

* * *

Two chorus girls were looking over a newspaper between acts. "Gee, look, Mame," pointed out one. "It says here that Mr. Adams, the octogenarian, has died. Now, what the heck is an octogenarian?"

"I dunno," replied Mame, "but they're sure a puny, sickly bunch. You never hear about one but what he's dyin'."

* * *

You've reached middle age when your wife tells you to pull in your stomach—and you already have.

* * *

Lots of people who buy on time don't pay that way.

* * *

Two black crows were talking. "Ah'll meet you at da post office in ten minu'es. If'n you git der first, draw a blue line on de sidewalk. If'n I git der first, Ah'll rub it out."

A farmer, whose prize milk cow was killed when she ventured on the railroad right of way, filed claim with the railroad for the value of the "critter." In due course of time the claim department forwarded a questionnaire as long as a quarter's worth of thread — to be returned before settlement of damages. After an all-day struggle the farmer came to the last item, reading: "Give disposition of animal."

The claimant jotted down, thoughtfully, "I think she was gentle."

* * *

"Why are you so happy, Mrs. Murphy?"

"Sure, me boy's comin' home today. He was sentenced up to 10 years in the penitentiary for running booze, but he got three years off for good behavior."

"Ah! I wish I had a son like that."

* * *

A little moron asked if you build a house from the bottom up or the top down. The man answered: "From the bottom up, you crazy fool."

Whereupon, the little moron yelled, "Come on down, Joe, we gotta' start all over."

* * *

Judge to Joshua (who had been picked up on suspicion): Are you the Joshua who made the sun stand still?"

Joshua: "No, sah, yer honah, Ah is the Joshua who made the moonshine still."

* * *

Overheard in the Ionian Room: "Consomme, bouillon, hors d'oeuvres, fricassee poulet, pommes d'terre au gratin, demitasse, des glaces and tell that mug in the corner to keep his lamps offa me moll, see!"

* * *

An old New England storekeeper was breathing his last and a sorrowful family surrounded his bed.

"Is May here?" he asked his wife wearily.

"Yes, Zeke," she replied. "And my oldest son?" "Yes." "And the other five boys?" "Yes." "And the four girls?" "Yes, Zeke," The failing patriarch struggled to a sitting position. "What's the big idea?" he shouted. "Who's tending the store?"

* * *

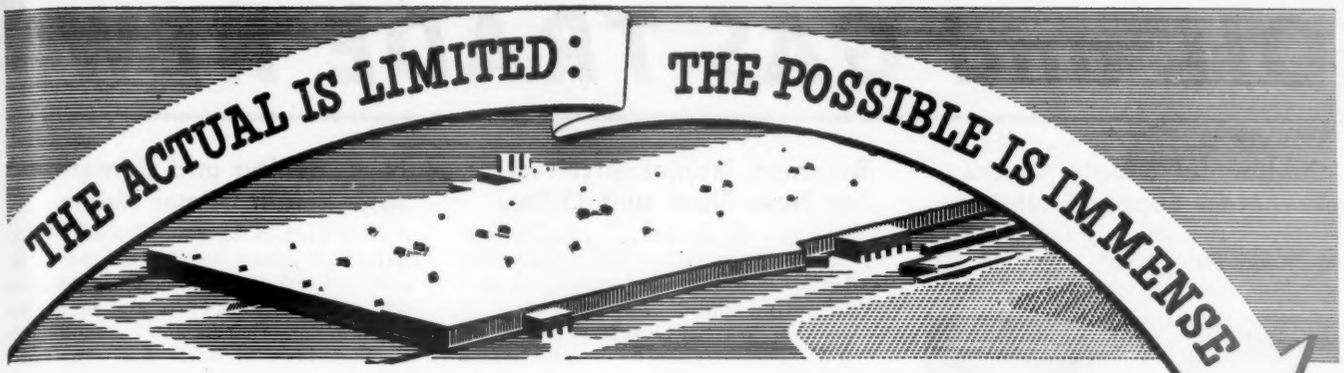
"Honey," said the husband, "I'd be the happiest man in the world if you could bake bread like my Mother used to bake."

"I know," his wife agreed. "But you know, dear, you would make me the happiest woman alive if you could just make dough like my Dad used to."

* * *

The lady of the house was entertaining her bridge club when she heard the pattering of little feet on the stairs. She raised her hand for silence. "Hush," she said softly, "the children are going to say their prayers. It gives me such a feeling of reverence to hear them—listen."

There was a moment of silence—then shyly, "Mama, Willie found a bedbug."



NEW LINCOLN PLANT CREATED BY INCENTIVE-INSPIRED CO-ACTION IN DEVELOPING POSSIBILITIES IN PRODUCT

© LE Co. 1952

ELIMINATES REJECTS ON HIGH PRESSURE PIPING with Lincoln high-current-density welding

SAVINGS in direct labor costs, as much as 30%, result from welding speeds 500% faster than hand welding. Welds produced are uniform, top quality, virtually eliminating scrap on this fabricator's critical high-pressure pipe joints. Assembly limits are actually held to within 1/8".

With the same flexibility of hand welding, "Manual Lincolnweld" provides the added production benefits of welding underneath a blanket of granular flux. High current density (600 amps on a 5/64" continuous wire electrode) produces a welding equivalent of 10,000 amps on a 5/16" electrode. Resulting penetration eliminates the need and cost of most joint preparation on plate sizes up to 3/4".

Fig. 3—Welds 5 times Faster. *High pressure fittings are welded at 18" per minute with "Manual Lincolnweld"s" high-current-density welding.*

Fig. 4—Manual Lincolnweld. *Compact, portable unit, operates from standard 600 amp Lincoln "Shield-Arc" welder.*

75 SECTIONS A DAY

Fig. 1—Double Joints 30" Pipe. *Third and final pass is made with "Automatic Lincolnweld" at 750 amps. One pass does what formerly required two hand passes to speed production.*

SAVES ON END-OF-SERVICE COSTS

Fig. 2—Reclaims Tool Joints *by adding Lincoln, low cost hardsurfacing to worn faces. Hardsurfaced tool joints are stronger . . . resist fatigue stresses from whipping of pipe.*

CUTS LABOR COSTS 30%

For additional data on "Manual Lincolnweld", write on your letterhead to Dept. 185,

THE LINCOLN ELECTRIC COMPANY

185 CLEVELAND 17, OHIO

THE WORLD'S LARGEST MANUFACTURER OF ARC WELDING EQUIPMENT

OIL and GAS TRADE NEWS

Continental Supply Opens Two New Supply Stores

The recent opening of two new stores by Continental Supply Company, Dallas, has been announced by Frank I.

Bill J. Veach

Vernon E. Hays

Brinegar, executive vice president. With Bill J. Veach as manager, a store has been opened in Glendive, Dawson County, Montana, at 314 South Clough Street. This store will operate under supervision of W. D. Craig, district manager, Casper, Wyoming. Also recently opened is a store at Hadacol Corners, Texas. This point is 35 miles south of Midland at the four corners of Reagan, Upton, Midland, and Glasscock counties. Vernon E. Hays is manager under the supervision of W. T. Hays, assistant district manager.

Beckman Instruments Buys Berkeley Scientific Company

The purchase of the business and assets of Berkeley Scientific Corporation, by Beckman Instruments, Inc., South Pasadena, California, has been announced by Dr. Arnold O. Beckman, president of Beckman Instruments. The Berkeley Scientific Corporation has been dissolved and the operations will continue as the Berkeley Scientific Division of Beckman Instruments, Inc. No changes in management or personnel are contemplated. W. K. Rosenberry, founder and president of Berkeley Scientific, becomes a vice president of Beckman Instruments, Inc., and will remain in charge of operations at the Richmond plant.

Five More Men Complete BJ Training Program

B. A. Hilliard, general sales manager, oil tool division, Byron Jackson Company, has announced that the oil tool-PB divisions factory training program, conducted at the main plant in Los Angeles, has completed the further training of five more OT-PB sales representatives. Among the five most recent representatives to complete the program was Jack "Export" Smith, Cliff Divelbiss, recently appointed California sales manager, Bill Jensen, newly appointed Mid-Continent engineer, Chet Smith, Houston, Texas, and Rhoal Lyles, Hobbs, New Mexico.

Beckman Names Architect For New Plant and Offices

Dr. A. O. Beckman, president of Beckman Instruments, Inc., South Pasadena, California, has announced that engineering and architectural firm of Donald R. Warren Company, Los Angeles, has been retained to design the new main plant and offices, which will be erected for the company on a recently acquired 45-acre site in the La Habra-Fullerton area. Plans call for an expandable design with an initial floor space of 200,000 sq ft. Helipot Corporation, a wholly owned subsidiary, will also move to the new plant. Helipot Corporation is the originator of the modern helical potentiometer.

New Bendix Sales Offices

The radio communications division of the Bendix Aviation Corporation has recently moved its commercial sales offices to a new location. Arnold Rosenberg, general sales manager, in an announcement, stated that greatly expanded activities of the sales department has necessitated the acquisition of additional space and that a one-story building had been acquired at 2120 North Charles Street.

Woobank Expands Facilities

The Woobank Machinery Company is now occupying new and larger quarters at 4950 East 15 Street, Tulsa, Oklahoma. For more than 30 years the company has been the representative of the C. Lee Cook Manufacturing Company, Louisville, Kentucky, for the sale of Cook graphitic iron piston rings and Cook metallic rod packings in the Mid-Continent area.

The move, which was made to accommodate the increased demands of the oil and gas industry, will provide Woobank with larger office space and increased warehouse facilities for carrying a more complete inventory of Cook piston rings and packings.

Woobank Machinery Company has opened its new and larger quarters (right) in Tulsa, Oklahoma. The company sells Cook graphite iron piston rings and Cook metallic rod packings.

N. Y. Belting and Gilmer Join; Retain Gilmer Name

New York Belting and Packing Company has joined forces with the L. H. Gilmer Company. The new organization will continue to operate and be known as New York Belting and Packing Company. Gilmer products will retain the Gilmer name and will be sold by the new organization. B. F. Ruether, vice president of New York Belting and Packing, will be in charge of the expanded organization.

Film on Instruments Out

"Information at Work" is the title of a 30-minute, full-color film on instruments put out by Taylor Instrument Companies. The film traces the development of instruments from those which do a relatively simple job to today's remarkable products used to indicate, record, and control the most complex processes. Film may be booked without charge through the public relations department of the company at Rochester, New York.

Gulf Coast Agent Named

Mud Products, Inc., Tulsa, Oklahoma, has named a Gulf Coast representative for Mudco O-Ring Butterfly valves, Henry H. Paris Distributor, Inc., of Houston, Texas. The new representative will serve all of Louisiana and Texas, with the exception of West Texas and the Texas Panhandle.

MM Distributors Named

Disher-Winslow, Ltd., of Edmonton, Alberta, was recently awarded a contract to handle the Minneapolis-Moline line of oil field engines in all parts of Canada. E. Disher is president and W. G. Boyd general manager of the company. Herbert Mayo is associated with the firm as field representative. The company is already stocking MM engines and replacement parts and is increasing its staff of service personnel.

New Houston Warehouse

Raybestos-Manhattan, Inc., announces the opening of a new Houston warehouse at 3012 Canal Street, which offers larger quarters with ample stocking facilities for servicing the expanding Gulf Coast industrial area. Principal products carried will be conveyor belting, transmission belting, V-belts, industrial hose of all types, and asbestos and rubber packings. The warehouse is in charge of M. C. Nugent and operates under the Dallas Office, E. W. Nagel, manager.

Raybestos-Manhattan, Inc., also announces the appointment of the Webster-Robinson Machinery and Supply Company, Inc., as a new distributor in Tacoma, Washington.

Griscom-Russell Holds 85th Year Celebration

The Griscom-Russell Company held a "Family Day" recently to mark the 85th birthday of the company, and at the same time to signalize the consolidation of its entire executive, administrative, engineering, and general sales departments at Massillon, Ohio. The celebration also provided the occasion to award specially designed gold emblems to employees of 25-year and 10-year standing.

During the celebration, more than 2100 employees and members of their families made guided tours of the plant to observe different phases of the company's manufacturing processes.

Represents Manzel

Manzel, manufacturers of force feed lubricators and chemical feeders, is now represented in the West Texas and New Mexico area by Ralph Nelson, of Midland, Texas. Nelson, a naval pilot in the last world war, has for a number of years served as a sales representative in the oil industry. His appointment is the latest step in Manzel's expansion program designed to provide more personalized field service in every oil producing section of the country. Manzel home offices are at 315 Babcock Street, Buffalo 10, New York.

Ralph Nelson

Gar Wood Stock Exchange

Gar Wood Industries, Inc., has approved the consummation of a stock exchange offer made June 16, 1952, to stockholders of United Stove Company, Ypsilanti, Michigan, who have tendered in excess of 80 per cent of the outstanding stock of United for exchange. One share of Gar Wood Industries common stock, $1 par value, will be issued for each three shares of United Stove Company, $1 par value, common stock. Gar Wood will continue to accept additional shares of United for exchange on the same basis for a limited time. According to Edward F. Fisher, Gar Wood president, United Stove will be operated as a subsidiary company, and will continue to manufacture its present products.

Deisel Engine Agents Named

Detroit Diesel Engine Division of General Motors announces the appointment of the Earle Equipment Company of Detroit as Michigan distributors of GM diesel engines to the petroleum industry. The company has been Detroit Diesel's industrial engine distributor in Michigan since 1948 and is now establishing engine sales and service facilities at Roscommon for oil well drilling.

Ball Expands Territory

Ball Distributing and Engineering Company of Tulsa, Oklahoma, distributor of Gustin-Bacon Manufacturing Company's Ultralite glass fiber insulation, has recently expanded its territory to include a warehouse and sales office at 819 North Olie Street, Oklahoma City, Oklahoma. Glenn Hughes, vice president of Ball, will be in charge of the Oklahoma City branch. Bill Linihan will be the new office manager.

Move Sales Office

Headquarters for A. O. Smith's New England sales operations were moved this month from Boston to Springfield, Massachusetts. The new office, under the direction of W. T. Halket, is at 95 State Street, Springfield. Telephone number is Springfield 9-7385.

POSITIVE OIL SHOW IDENTIFICATION with MINERALIGHT Ultra-Violet

(BLACK LIGHT)

Make sure you don't pass up possible pay! Make positive core identification checks with new model MINERALIGHT SL long wave ultra-violet lamp.

Proved best by test for oil show analysis!

No experience needed to operate. Lamp weighs only 1 lb. Models available for 110 volt AC or with adapter, 110 volt DC current. Battery operated model for field use holds lamp, has built-in viewer for daylight examination. Easily portable.

FREE

Send for illustrated brochure on how to detect and analyze petroleum in oil surface samples with ultra-violet.

ULTRA-VIOLET PRODUCTS, INC.

Dept. PE 145 Pasadena Ave., South Pasadena, Calif.

TO: The Petroleum Engineer
P. O. Box 1589 • Dallas

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Refinery saves $4310 cleaning storage tank

HERE'S the way a Southwestern refinery cuts tank cleaning costs from $4800 to $490—gets a better cleaning job, too, and in only 12 hours.

They just spray recommended Oakite solvent detergent solution on tank sides and supporting columns—then finish off with a high pressure rinse. All the equipment they need is a solution tank, pump, hose, piping, and scaffold.

Try it yourself. Ask your Oakite Technical Service Representative, or write Oakite Products, Inc., 48 Rector St., New York 6, N. Y.

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MATERIALS • METHODS • SERVICE

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Trade News

Technical Sales Unit

A technical sales unit, designed to render technical service on problems particularly related to heat transfer and product fabrication, was announced by John M. Dumser, director of sales of the Wolverine Tube Division of Calumet and Hecla Consolidated Copper Company. This new unit will be headed by C. H. Kuthe, manager of technical sales. He will be assisted by L. J. Bonacor, R. B. Davis, and H. C. Flesch.

Davison Begins Work On Superphosphate Plant

Construction of a plant for the production of triple superphosphate has begun at Ridgewood, near Lakeland, Florida, by The Davison Chemical Corporation of Baltimore. Davison, a major producer of phosphate rock and normal superphosphate, as well as mixed fertilizers and general industrial chemicals, will for the first time become a producer of triple superphosphate when the new plant is completed. Plant is scheduled for completion October 1, 1953.

New Kentucky Plant Open

Winslow Engineering Company of Oakland, California, has announced that its new Murray, Kentucky, plant is now in operation. This is the first Winslow plant outside of California. Joseph L. Kern is in charge of operations at the new Kentucky factory, which expects to be turning out filters as well as elements by early fall.

New Houston, Texas, plant of Perforating Guns Atlas Corporation.

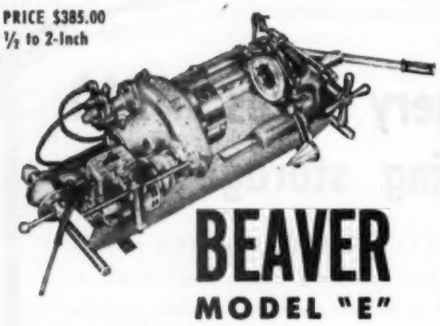
New PGAC Plant Operations

Perforating Guns Atlas Corporation has moved part of its facilities to the new plant at Holmes Road and Scott Street, Houston, Texas. Paul Charrin, president of PGAC, said field operations divisions for simultaneous radiation logging, bullet and jet perforating, have been transferred from the old plant to one of the buildings already erected, and field operations garage division now occupies a second building for servicing and repairing the many trucks and cars. A third building of several yet to be built is now under construction, according to J. H. Castel, executive vice president of the company.

Redwood By-Products Use

With the appointment of William G. Van Beckum as director of research and development, the Pacific Lumber Company has announced plans for further development of redwood by-products for use in oil well drilling. Some years ago, the firm introduced "Palco Seal," a redwood fiber lost circulation product, that is widely used in the drilling industry. Recently, the Pacific Lumber Company introduced Palcotan, which is finding application as a replacement for Quebracho in the conditioning of drilling muds. In previous capacities, Van Beckum has been closely associated with the development of new drilling products.

PRICE $385.00
½ to 2-inch



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MODEL "E"
pipe and bolt machine

● Cuts, threads and reams all kinds of pipe from ⅛ to 2-inch. With a drive shaft and geared tools cuts and threads pipe up to 8-inch. Cuts off bolts and rods up to ⅞-inch. Threads bolts and rods to 1½-inch in one cut; up to 2-inch in two cuts.

Write Beaver for detailed bulletin—or order through your supply house!

"Over 50 Years of Friendly Service"

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256-300 Dana Ave.
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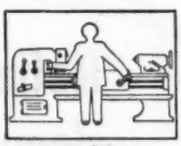
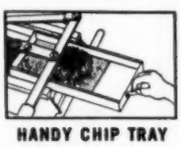
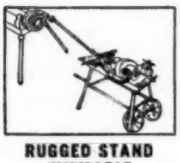


RIGHT-HANDED

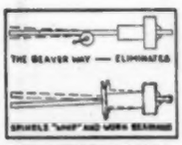
GEARS RUN IN OIL



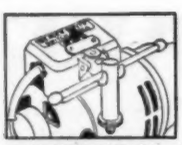
HANDY CHIP TRAY



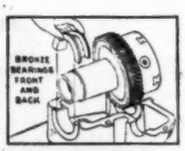
RUGGED STAND AVAILABLE



NO SPINDLE WHIP

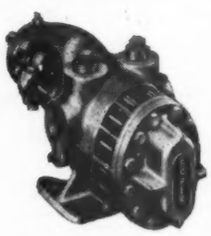


SAFETY SWITCH LOCK

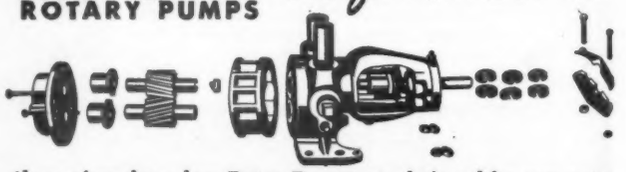


RENEWABLE BRONZE BEARINGS

Savings that Pay Off...



ROPER ROTARY PUMPS are quick to Service



Above view shows how Roper Pumps are designed for easy accessibility. Not necessary to disturb pipe connections or mountings.

When an installation requires inspection because some destructive foreign element causes trouble, quick servicing design cuts down-time to a minimum and speeds the job. Furthermore, Roper replacement parts are interchangeable and available on all current models.

The exploded view above shows the detail of disassembly of a Roper Series F Pump . . . available for pressures up to 300 P.S.I. — built in 13 sizes up to 300 G.P.M.

Write for Catalog Today
Capacities to 300 g.p.m.
Pressures to 1000 p.s.i.
GEO. D. ROPER CORP.
729 Blackhawk Park Avenue
ROCKFORD, ILLINOIS

ROPER Rotary Pumps

TEMA Elects New Officers for 1952-53

Officers for the coming year in the Tubular Exchanger Manufacturers Association (TEMA) were recently elected at the annual meeting of the association. The three-day conference was held at Skytop Lodge, Skytop, Pennsylvania, late in June. Elected to head the organization were J. E. Hughes, president, and G. A. Worn, vice president. Hughes is director of the heat transfer division of the Western Supply Company of Tulsa. Worn is manager of the heat exchanger department of the Lummus Company of New York. Re-elected as secretary-treasurer was George P. Byrne, Jr., also of New York.

TEMA is a group of independent shell and tube heat exchanger manufacturers organized to further the standardization of mechanical construction and detail of heat transfer equipment. The association is also active in research and development in determining heat transfer rates to be employed in the petroleum, petrochemical and chemical industries.

The most recent notable accomplishment of the association was the issuing of its third edition of the "Standards of Tubular Exchanger Manufacturers Association", a 150-page technical book, covering the thermal and mechanical standards of both carbon steel and alloy heat exchangers. This third edition also contains an extensive section dealing with thermal standards and reference data required in the sizing of heat exchangers.

Serving on the executive committee of TEMA throughout the coming year will be J. E. Hughes of Western Supply Company, G. A. Worn of the Lummus Company, W. C. Beekley of Whitlock Manufacturing Company and E. E. Dillman of Engineers and Fabricators, Inc.

Barrett Opens Research Lab

A new laboratory, specially designed to develop and test materials and processes used in the manufacture of plastics, rubber products, paints and varnishes, paper, laminates, insulating materials, and a wide range of other products was opened recently by Barrett Division, Allied Chemical and Dye Corporation. The laboratory will be known as the Shadyside Applications Research Laboratory, and will be in charge of D. A. Rankin, superintendent.

Gardner Denver Trains Republic Supply Salesmen

Gardner Denver Company, manufacturers of slush pumps and other equipment for the petroleum industry, recently gave a course in the application and servicing of their products to eleven salesmen of the Republic Supply Company of California at its plant in Quincy, Illinois. The entire week of June 15 was devoted to intensive study which would enable each of those who attended to become thoroughly familiar with the merits and uses of these Gardner Denver products.

The Republic Supply Company of California is the sole stocking distributor of Gardner Denver oilfield slush pumps for California, and the trip to the Middle West was part of Republic Supply's continuing program for rendering better sales service by equipping all company representatives with complete technical information about the products they distribute.

Republic Supply executives and salesmen who went east for this course were selected by W. Dale Russell, Republic's vice president and general sales manager, from company branches all over California. Members of the party came from Los Angeles, San Leandro, Fresno, Newhall, Bakersfield, Taft, Santa Maria, and Avenal.

Allis-Chalmers Expands

Allis-Chalmers Manufacturing Company has purchased the plant of Victor Electric Products, Inc., in Cincinnati, Ohio, according to an announcement by J. L. Singleton, vice president in charge of the firm's general machinery division.

Singleton said that purchase of the plant fills a long-felt need for additional space and shipping facilities for Texrope drive equipment. Within the next few months all Texrope sales, engineering and production facilities will be moved into the new plant from West Allis. The newly acquired plant contains offices, cafeteria, manufacturing, warehouse and shipping facilities.

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Trade News

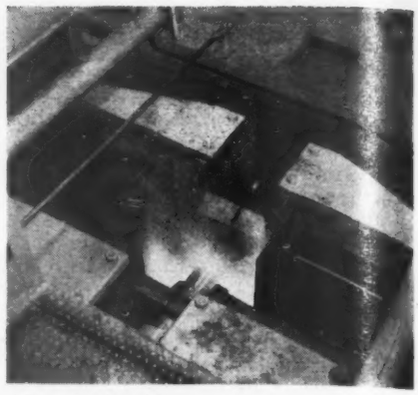
Tube Turns Notes Silver Anniversary

Tube Turns, Inc., celebrated its 25th anniversary recently. It was incorporated on July 19, 1927, making forged seamless welding fittings available for directional changes in piping systems. The company's general offices, main plants, and engineering and research facilities are in Louisville, Kentucky. In 1948 the company purchased the Pennsylvania Forge Corporation of Philadelphia, manufacturers of forged steel flanges. In 1948, a subsidiary, Tube Turns of Canada, Ltd., was established in Chatham, Ontario. George O. Boomer is president of Tube Turns, and John G. Seiler is executive vice president.

Aquatrol, Inc., Reorganized By M. C. Forbes, President

By purchase of a large block of outstanding stock from other interests, M. C. Forbes, president of Aquatrol, Inc., has secured control of the company, according to a company announcement. Forbes has also completed a major reorganization of Aquatrol, Inc., the prime objective of which is to better serve their many customers throughout the country.

Aquatrol, Inc., specializes in industrial water control, serving many of the nation's largest refineries, power and manufacturing plants using water for industrial cooling systems, boilers, air-conditioning systems, and for a host of other purposes.



New flashwelding facilities of American Iron and Machine Works.

Flashwelding Facilities

The American Iron and Machine Works Company of Oklahoma City has recently expanded its flashwelding facilities for attachment of tool joint to drill pipe by the installation of a new flashwelding machine installed at their No. 2 plant in Oklahoma City. The new swift electric flashwelder is the fifth of its kind to be manufactured and one of the largest in existence. This machine will enable the company to increase the productive capacity of flashwelding new tool joints to old and new pipe.

GE Booklet Reports Prime Contractors

General Electric Company has published a 32-page booklet entitled "It Takes All of Us" in which it discusses what kind of business makes the best defense contractor. The GE booklet reports that all kinds of businesses are needed to do a particular job. For example, GE's production of defense items depends upon more than 17,000 subcontractors, suppliers, and service organizations. On the jet engines alone, the booklet reports, more than 4000 suppliers directly serve the General Electric Aircraft Gas Turbine division.

Kansas Company Named Oil Country Sales Division

Carlon Products Corporation has announced that the Green Contracting and Engineering Company, 103 South Vine, Wichita, Kansas, has become the oil country sales division of the organization. This makes available to the petroleum industry the engineering services of this company in conjunction with the research, production, and the plastic pipe of Carlon Products. As a distributor of Carlon for the past four years, Green has pioneered in the application of plastic pipe in the petroleum industry, and now as an integral part of the Carlon sales organization, they will make this engineering and applicational knowledge available to supply houses and distributors servicing the oil country installations. The new affiliation provides increased capacity.

Carlon plastic pipe and tubing have proved particularly applicable for crude oil, raw gas, salt water, lead, gathering, gasoline, disposal and fresh water lines.

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GOOD PRODUCTS BETTER...
Harrisburg's Production-Management-Sales Team
Brings You The
BEST COUPLINGS AND FLANGES IN THE INDUSTRY!
Harrisburg Seamless Steel Pipe Couplings are made to A.P.I. and A.I.S.I. specifications for line, casing, merchant, drill and drive pipe.
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HARRISBURG FLANGES
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99 Years in Pennsylvania's Capital
Harrisburg Steel
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PENNSYLVANIA
CHECK OUR CURRENT PRICES NOW. Write today stating quantities and types you need . . . or contact your Harrisburg Steel distributor. Copies of Coupling and Flange catalogs mailed on request.

TRADE PERSONALS

Harvey F. McClellan has been appointed representative for Toledo Pipe Tools in Delaware, Maryland, New Jersey, southern part, Pennsylvania, Virginia, and Washington, D. C. McClellan will make his headquarters in Philadelphia. **William L. Gahman,** formerly in charge of this territory, will transfer to the New York City area where he will assist **Clarence A. Popp,** eastern manager of sales. Gahman has been with Toledo since 1938.

H. F. McClellan

Wm. L. Gahman

Arthur C. Bryan has been appointed vice president in charge of sales for National Carbon Company, a division of Union Carbide and Carbon Corporation. He has been with National Carbon in various sales activities since 1935. He joined the company as an industrial salesman in the Chicago office.

Arthur C. Bryan

G. T. Van Alstyne has been appointed director of advertising and publicity of Air Reduction Company, Inc. **George M. Worden,** recently with Hill and Knowlton, Inc., public relations counsel, rejoins the company as assistant to the director. Van Alstyne is succeeded as advertising manager of Air Reduction Sales by **A. V. Scherer,** formerly advertising manager of the Ohio Chemical and Surgical Equipment Company division. Scherer is succeeded at Ohio Chemical by **Henry W. Beck.**

Paul Bartley

L. E. Jones

Paul Bartley, formerly Lafayette, Louisiana, branch manager, has been named assistant regional manager for the Gulf Coast region, Black, Sivalls and Bryson, Inc. **Ralph A. Stevens,** Houston, is manager of the Gulf Coast Region. **L. E. "Buck" Jones** formerly Alice branch manager, is named assistant regional manager covering the Houston and Alice branches in the Gulf Coast region. Appointed assistant regional managers for the West Texas region are **Ed Pool,** formerly Odessa branch manager and **Ed Reif,** formerly Casper branch manager. **H. C. Fessler,** Midland, is manager of the West Texas region.

Rodney V. Nilsson, who has been in the tin plate sales, The Youngstown Sheet and Tube Company for six years, has been appointed manager of that department. **R. Paul Broadhurst,** a member of the Chicago district sales staff for two years, has been appointed assistant district sales manager for the Chicago territory.

George J. Greaney, Jr., has opened up a new office for the Elliott Company at 731 Wilson Building, Corpus Christi, Texas. The Elliott Company has headquarters at Jeannette, Pennsylvania. Greaney for the past four years has been a field engineer in Elliott Company's Houston office. He was graduated from Texas A & M.

Robert R. Anderson has been appointed advertising manager of Dearborn Chemical Company. He was formerly with the advertising staff of Fairbanks, Morse and Company. This appointment fills a vacancy created by the resignation of **Earl J. Goris.**

R. F. Muenster

A. L. Murry

R. F. Muenster, Mid-Continent Supply Company, has been promoted from store manager at Wichita Falls, Texas, to North Texas district machinery manager, and **A. L. Murry,** former Wichita Falls field salesman to store manager at the same location.

Muenster attended the University of Texas, and has served Mid-Continent Supply for six years. Murry has been with Mid-Continent Supply six years, four as field salesman at Wichita Falls. He attended Texas A and M.

Ed Pool

Ed Reif

G. F. Goetzinger has been named vice president-treasurer of the Oil Well Supply division of United States Steel Company. Goetzinger has served as treasurer and general credit manager since 1946. He is a veteran of 39 years service, having joined the organization in 1914.

G. F. Goetzinger

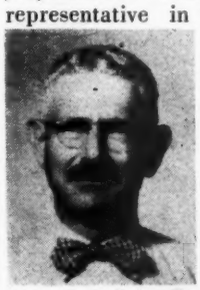
Kenton Chickering

Kenton Chickering has been promoted to general sales staff manager of United States Steel's Oil Well Supply Division and **N. K. Schnaitter** will succeed him as manager of the commercial research section.

Chickering succeeds **M. F. Jones,** who recently was appointed Gulf Coast area manager at Houston, Texas. He is a veteran of nearly a quarter of a century with "Oilwell" and his service represents a family tie that dates back to the organization's founding 90 years ago. His grandfather was the original Kenton Chickering, one of the leaders in the establishment of the business in 1862, and his father also spent a great part of his life with "Oilwell." Chickering joined "Oilwell" in 1928 at its Imperial Works in Oil City following graduation from Lehigh University.

Schnaitter began his service with United States Steel in 1946 as a sales analyst with the American Steel and Wire Division in Cleveland, Ohio, after graduation that year from the University of Pennsylvania's Wharton School of Commerce and Finance. At the time of his newest appointment he was senior statistical analyst.

Lynton L. Scharff is new Manzel representative in the Arkansas and Northern Louisiana areas. Scharff for some years engaged in the contracting business and more recently served as sales representative for several manufacturers. Manzel home offices are at 315 Babcock Street, Buffalo, New York.



Lynton L. Scharff

Harry P. Conroy, one of Halliburton Oil Well Cementing Company's three regional vice presidents has been transferred from the southern region to the northern region; **Fred R. Whitten** transfers from the northern region to the central region; and **R. G. Kelly** transfers from the central region to the southern region.

Vice presidents Conroy, Whitten, and Kelly will continue to have headquarters at Duncan, Oklahoma, home office. Duties in their new assignments remain the same.

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Now Available!
Oil Companies interested in the Williston Basin will want these complete, accurate new maps that include land ownerships, lease ownerships and important mineral ownerships together with other valuable information on dry holes, producing wells and current drilling operations. Consists of 92 maps printed on durable 24" x 24" paper. Scale 3" to the mile. Price $10 per map. Send for complete information.
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TABLETS REMOVE AND PREVENT RUST AND SCALE IN ALL RADIATOR COOLING SYSTEMS
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REMOVES AND PREVENTS BOILER SCALE AND CORROSION
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Trade Personals

Lawrence Litchfield, Jr., has been elected president of Alcoa Mining Company, New York City, and of Surinaamsche Bauxite Maatschappij, Paramaribo, Suriname, both subsidiaries of Aluminum Company of America. He succeeds **Frank B. Cuff,** who is retiring August 1.

Litchfield, who has been serving as vice president of Alcoa Mining Company and Surinaamsche Bauxite Maatschappij, is a veteran of 27 years service with the company. He is a graduate of the United States Naval Academy in Annapolis.

Litchfield has traveled extensively all over the world examining mineral deposits and is an authority in the bauxite field, having published numerous technical papers and articles on that subject. He is a member of the National Minerals Advisory Council, of the Natural Resources Committee of the United States Chamber of Commerce, and of the Land Use Committee of the American Mining Congress. He also is a member of Alcoa's technical committee.

Frank B. Cuff, born in Manchester, England, is a graduate of New York University. He started his business career with U. T. Hungerford Brass and Copper Company, New York, and later spent several years in the public accounting business before joining Republic Mining and Manufacturing Company (now Alcoa Mining Company) and Surinaamsche Bauxite Maatschappij in 1916 as accountant. He subsequently was treasurer, vice president, and president of both companies, attaining the latter position in 1937.

In recognition of Cuff's interest in and contribution to the development and progress of Suriname, a Dutch territory in South America, he was in May of 1952 decorated by Queen Juliana of Holland, being made an officer in the order of Oranje-Nassau.

W. A. Finn has been named assistant general sales manager of Worthington Corporation, according to an announcement by T. J. Kehane, assistant vice president and general sales manager. Finn, who is returning from Paris, France, where he has been serving as general European manager, will now make his new headquarters at Worthington's Harrison, New Jersey offices.

Finn was graduated from the Naval Academy at Annapolis in 1922 and served in the U. S. Navy until 1926. He then joined Worthington as an application and sales engineer in the steam power division.

A. Callaway Allen was appointed sales manager of electrical division of Wagner Electric Corporation to succeed H. A. Hudson who has a new position as sales analyst for the company.

Allen began his career with the Wagner company in 1930 immediately after graduating with a BS in engineering from University of Illinois.

After a student engineering training with the company Mr. Allen entered the sales department. He was manager of the Wagner electrical sales branch at Memphis when he was promoted.

Heath Robertson Weil

H. H. Heath has been appointed comptroller for the Baroid Sales Division, National Lead Company, with national headquarters in Houston, Texas. With Baroid since 1943, he has also served as chief accountant and assistant comptroller. Prior to that, he was associated with the Firestone Tire and Rubber Company in Los Angeles. Heath is a graduate of Loyola University of Chicago and did graduate work at UCLA.

Gordon Robertson has been appointed assistant comptroller for Baroid. He has been with the Baroid organization since May, 1949. Robertson holds a BBA degree from the University of Minnesota.

Ben A. Weil has joined the advertising department of Baroid. Prior to this association, he headed his own advertising agency in Corpus Christi, Texas. Weil received his education at the University of Texas, having graduated in 1948 with a degree in Business Administration.

Otto J. Blank, formerly plant manager of the R. M. Hollingshead Corporation, has been appointed vice president in charge of production for the Camden, New Jersey, chemical firm, according to an announcement by President Wilbur H. Norton.

As Hollingshead plant manager in charge of production for the past eight years, Blank has been responsible for production and shipping at the corporation's several plants in the Camden area and in Bowmanville, Ontario, Canada.

Before joining Hollingshead, Blank was associated for 28 years with Peck, Stow and Wilcox, Connecticut hardware manufacturers, as works manager and later as vice president of operations.

Charles Carl Carr, who retired in 1949 as director of public relations and advertising for Aluminum Company of America died suddenly at 11:30 p. m., Tuesday, July 29, of a heart attack, in St. Petersburg, Florida, where he has resided since retiring from ALCOA. Carr began his career with ALCOA in 1934 as advertising manager. He was made director of public relations and advertising in 1944. Since his retirement, he has been a public relations consultant at St. Petersburg.

Robert C. Luckey has been appointed safety engineer for Chemical Plants Division, Blaw-Knox Construction Company. He will be responsible for the organization and administration of accident and fire prevention at Chemical Plant's field construction projects.

He is a graduate of Northwestern University in industrial engineering and had special courses in accident and fire protection.

Trade Personals

Sam B. Jones

Robin Knight

M. L. Van Wagner

R. L. Walker

M. L. Van Wagner was appointed assistant eastern division manager of McCullough Tool Company, with headquarters at Houston, Texas; **Robin Knight** was promoted to senior salesman at the McCullough Oklahoma City district office; **R. L. Walker** promoted to branch manager at Snyder, Texas; and **Sam B. Jones** to branch manager at Hadacol Corner, Texas, it was recently announced by I. J. McCullough, president.

Van Wagner started with McCullough in 1947 and advanced rapidly in service work to become safety engineer of the eastern division of the company in 1950. His new duties as assistant eastern division manager will still include supervisory control of the safety program.

Robin Knight, with McCullough since 1948, has held many governmental executive position, both in the State of Oklahoma and in Oklahoma City. He has also been a general manager for three prominent Oklahoma City firms during the past twenty years. Knight's new duties as senior salesman will consist chiefly of city sales work in Oklahoma City.

R. L. Walker joined McCullough shortly after his Army service in World War II. Beginning as a rigger in Oklahoma in 1944, he has worked in the oil fields of Texas, Oklahoma, and New Mexico.

Sam Jones joined McCullough in 1947 as a rigger at the Hobbs, New Mexico branch. Because of his wide range of experience, Jones was appointed manager when McCullough opened a new service branch at Hadaco. Corner, Texas.

Raymond S. Clark has been appointed counsel for The Davison Chemical Corporation, according to Chester F. Hockley, president. Clark, a graduate of Groton, Harvard College, and Yale Law School (1939), was engaged in private law practice before joining Davison in June of last year. Clark will succeed H. Alexander Smith, Jr. Smith who has been with Davison since 1948 is leaving the company to devote his entire time to his personal interests.

William H. Old has joined The Babcock and Wilcox Company as director of purchasing. He will be in the New York office of the company. Old is a native of Virginia. He attended the Virginia Military Institute and the Harvard Business School. He was formerly general purchasing agent of American Brake Shoe Company.

Thomas W. Russell, Jr., was appointed general purchasing agent of American Brake Shoe Company. Russell was graduated from St. Georges School and Yale University. He joined American Brake Shoe Company as an apprentice in 1945 and entered the purchasing department as a buyer in 1949 and became assistant general purchasing agent in 1950. During World War II Russell served five years in the U. S. Army attaining the rank of captain.

Jim Camp, who has been in charge of the Tulsa, Oklahoma, office of the plate and welding division of General American Transportation Corporation, for the last two years, has been transferred as district sales manager of the Houston, Texas, office. **Jim Wallace** has been transferred from the engineering department of General American to become sales engineer of the plate and welding division, Tulsa.

Robert McCoy, Jr., vice president, has retired from the Jones and Laughlin Supply Company where he had completed 39 years of continuous service on July 7, 1952, it has been announced by J. L. Shakely, president of the company. Born and reared in Pittsburgh, Pennsylvania, McCoy left his home in Pittsburgh in January, 1913, for a visit in Tulsa and nearby oil fields. Deciding to remain in Oklahoma, he went to work as a laborer for a gas company in Cushing, leaving them the following July 1 to join the employ of Frick-Reid Supply Company (now Jones and Laughlin Supply Company) on July 7, 1913, as a storeman at Cushing. Promoted to store manager of the Cushing store in 1913, he guided the activities of this store through the stirring days of the great Cushing boom, and in 1916, was transferred to Drumright, Oklahoma store as store manager. Bob was elevated to the position of district manager and remained in Drumright until 1922, when he moved to Tulsa. And later he was appointed sales manager of the company's Western Division at Tulsa. He was elected vice president and a director of the company July 22, 1938, at which time the general offices were moved from Pittsburgh, Pennsylvania, to Tulsa.

Robert McCoy, Jr.

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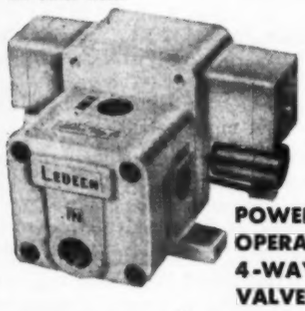

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Trade Personals

Phillips Wright Cook

▸ **H. B. Phillips** has been appointed sales manager, quantity sales division, Cutler-Hammer, Inc. **F. A. Wright** has been named sales manager, district sales, and **J. M. Cook** has been appointed sales manager, industrial control divisions. Graduates of Michigan University, Phillips joined Cutler-Hammer in 1911, and Wright joined Cutler-Hammer as a student engineer in 1927. Cook joined Cutler-Hammer upon graduation from University of Minnesota in 1928.

▸ **Jack E. MacConville** has been named to regional industrial sales manager by Minneapolis-Honeywell Regulator Company, and will have charge of the southeast regions with headquarters in Atlanta, Georgia. Other new regional managers are: **Alfred J. McCullough,** central region, headquarters in Cleveland, Ohio; **Howard L. Marston,** northwest, headquarters in Minneapolis; **Robert L. Mallory,** Southwest, headquarters, Dallas, Texas. **Robert B. Grant,** Pacific and Mountain region, Los Angeles, and **Lester W. Williams,** Pacific Northwest, Portland, Oregon.

▸ **James B. Armstrong** has been appointed credit manager of the Spang-Chalfant Division of The National Supply Company. Armstrong, who had been assistant division credit manager, succeeds **Alvin D. Lowdermilk,** who retired after 32 years with the company.

Griffin Fleming Bracewell

▸ **W. H. Griffin** has been promoted from Gulf Coast division manager, Welex Jet Services, Inc., to the newly created position of assistant to **A. M. Birnie,** sales manager. In his new position, Griffin will participate in overall management problems throughout the entire Welex service area. Griffin will maintain his headquarters in Houston.

J. B. Fleming has been promoted from Corpus Christi district manager to take the place of Griffin as the Gulf Coast division manager and will move his headquarters to Houston. **L. M. Bracewell,** formerly Fleming's assistant, has been promoted to Corpus Christi district manager. Welex has moved its West Texas Division offices from Odessa to Midland and are located in the Central Building there. **Wayne Satterwhite,** division manager, has moved his headquarters to the new Midland location.

▸ **George McCuskey** has joined Youngstown Sheet and Tube Company as assistant to the president. His duties will be devoted primarily to financial phases of the industry. McCuskey attended Kent State University, received his BA from Denison University, and his bachelor of laws degree from Cleveland Law School. For the last seven years has been associated with Perfection Stove Company in Cleveland.

▸ **R. H. Morse, III,** has been appointed general manager of Fairbanks, Morse and Company's Beloit, Wisconsin, works. This marks the fourth generation of the Morse family to come to the management staff of the company. Morse succeeds **Orren S. Leslie** as general manager of the company's largest manufacturing plant. Leslie has been named manager of manufacturing and has been transferred to the company's headquarters in Chicago.

Ferguson Mendenhall Teel

▸ **L. T. Ferguson,** tri-state area representative for The Guiberson Corporation, has been transferred to Odessa, Texas. With Guiberson more than 11 years, he was replaced in that area by **W. V. Phillips,** with headquarters at Salem, Illinois.

R. Z. (Bob) Mendenhall, Southwest Texas representative for Guiberson, has been transferred to Corpus Christi, Texas. Mendenhall has been in Victoria, Texas, as Southwest Texas representative for Guiberson.

C. A. (Cliff) Teel, West Texas representative for Guiberson has been transferred to San Angelo, Texas. Teel has been in Odessa, Texas, as a West Texas representative.

▸ **John J. Redmon** has been appointed manager of the A. O. Smith product service branch at Dallas, Texas, succeeding **Ben Heald** who is returning to full time sales activity for A. O. Smith. Redmon was formerly associated with Johnson Motor Lines of Denison. **J. W. Rushing** has been appointed assistant manager. Rushing joined A. O. Smith in October, 1949.

John G. Leyh

▸ **John G. Leyh** has been appointed assistant sales manager of Franks Manufacturing Corporation.

Leyh, who has been with Franks for 12 years, was assistant service manager prior to his current appointment.

Taylor Milton has been appointed vice president by Walter Kidde Constructors, Inc., engineers and builders.

Milton has been vice president and chief engineer of Walter Kidde Engineer-Southwest, Inc., a subsidiary with headquarters in Houston. He will continue in this capacity, in addition to carrying out his new duties.

A member of the Walter Kidde Constructors organization for several years, Milton was formerly associated with the Austin Company in Michigan and New York. He is a graduate of Texas University and holds a master's degree from Columbia University. He is a registered professional engineer and a registered architect.

William G. Van Beckum, formerly manager of technical service and assistant sales manager, special products division of Weyerhaeuser Timber Company, becomes director of research for Pacific Lumber Company in San Francisco.

C. L. Peterson was made general sales manager of the Industrial Division of Minneapolis-Honeywell Regulator Company recently, it was announced by L. Morton Morley, vice president of the division.

Peterson has been regional manager for Honeywell's midwest region in Chicago since January, 1950. He succeeds W. H. Steinkamp. An engineering graduate of the University of California, Peterson joined the company in 1927 as sales engineer in the San Francisco office. In 1945 he was appointed regional manager for the parent company's Pacific region.

Gordon R. Graham was named administrative assistant, controller's office and **Alwyn F. Yeatman** was selected to succeed Graham as general auditor, it was announced by The National Supply Company, Pittsburgh, Pennsylvania.

Graham has been identified with the company since 1945, and became controller of the company's Spang-Chalfant Division plant in 1946. He was appointed general auditor of the company in 1949. Yeatman joined the company in 1949. He was named assistant general auditor in 1951.

Clyde J. Stottlemyer has been appointed assistant plant controller at the Toledo, Ohio, plant, National Supply Company. Stottlemyer has been with the company since 1937, when he was employed as a clerk at the engine division plant in Springfield, Ohio. He was formerly staff cost accountant in Pittsburgh.

C. A. Franklin, Jr., has been appointed western district sales manager of the New York Belting and Packing Company, it was announced by B. F. Ruether, vice president. His territory extends from the Rocky Mountain states to the West Coast, from the Canadian border to the Mexican border and the Hawaiian Islands. Franklin has been with the company for 17 years. He succeeds O. L. Wall who died June 29.

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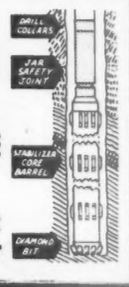

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Trade Personals

Vernon L. Durrstein, special design engineer for National Supply Company engine division for the last eight years, has been appointed assistant chief engineer of that division, with headquarters at Springfield, Ohio. Durrstein was graduated from the University of Illinois in 1931. Prior to joining National Supply he served as a design engineer with Cummins Diesel Engine.

V. L. Durrstein

E. R. Blair, Jr., was appointed sales and service manager for Whitmor it was announced by Burl Johnson, vice president and general manager of Whitmor Homebuilders, Inc., Tulsa, Oklahoma. Blair was associated for 15 years with the William Cameron Company. For the past year he was factory representative for the Certanteed Products Corporation of Amarillo, Texas.

J. W. Ross has been appointed Philadelphia district manager for Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation, it was announced by W. F. Reich, Jr., vice president.

Ross, who joined the company in 1936, moves up to fill the position formerly held by **R. M. Joslin, Jr.**, who has been appointed midwestern division manager for the company in Chicago. Carbide and Carbon Chemicals Company has its sales offices in the Philadelphia Savings Fund Building, 12 South 12th Street. The company sells over 350 different industrial chemicals, has warehouses in 80 cities, sales offices in 19 principal cities, four large chemical plants and three research centers, plus fellowships at many leading colleges and universities.

Raymond T. Whitzel has been made general manager of the smelting division of Aluminum Company of America, succeeding **V. C. Doerschuk**, who has been general manager of that division since 1935. Doerschuk will become technical consultant, chiefly on aluminum smelting and related problems.

Whitzel, a veteran of 37 years' service with ALCOA has been assistant manager of the smelting division since March, 1951.

Doerschuk began his career with ALCOA in 1910 at the Niagara Falls works. He was responsible for staffing and operating the Alcoa and Defense Plant Corporation's smelting plants during World War II.

Earl F. Adams has been named assistant chief engineer of Weston Electrical Instrument Corporation's Tagliabue division. Adams was formerly the pyrometer group chief of this division. He joined Weston 29 years ago.

Joe H. Dunlevy has been named district manager of The Garlock Packing Company's Los Angeles office at 2303 East Eighth Street. From 1919 to 1929 Dunlevy was a Garlock sales representative operating from Cleveland, Ohio office. Then for two years he acted as a special representative for the vice president in charge of sales. Since 1930 his headquarters have been at Palmyra, New York where Garlock's main office and factories are located, serving as a consultant on mechanical packing problems for the entire company as well as Garlock's special representative contacting the Army and Navy in Washington, D. C.

Joe H. Dunlevy

Dunlevy succeeds **Clarence W. Harmon**, district manager of the Garlock Los Angeles office for the past 25 years, who, due to ill health, is being retired by Garlock on July 31.

John Deaderick has been named manager of the Philadelphia office of the Foxboro Company. **Joseph Esherick**, district representative of The Foxboro Company in Philadelphia for many years, now devotes his entire attention to special accounts, serving as manager of that department. Deaderick received his engineering training at Texas A & M.

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Fred W. Ayers, senior vice president and general manager of Hughes Tool Company, has been invited by the Chamber of Commerce of the United States to serve on the Department of Manufacture Committee for the coming year. The committee advises the Chamber's board of directors in developing and recommending policies in the field of industrial problems. The committee also studies means of putting into effect policies that are adopted by the Chamber's membership.

Fred W. Ayers

F. W. Berdan has been appointed manager, automotive products sales and **J. F. Warnell,** manager, battery products sales, National Carbon Company, Union Carbide and Carbon Corporation. Both executives will be in the company's general sales offices in New York. Berdan joined the company as a salesman in 1922. He is in charge of sales of "Prestone" and "Trek" anti-freezes and other automotive products. Warnell joined National Carbon as a salesman in 1933. He has charge of sales of "Everready" flashlights and batteries.

William T. Box has been named executive assistant on the general office staff at BJ Service, Inc. Box has been an employee of Byron Jackson Company for the past 12 years. During the last 5 years he was associated with the research and development work on the jet process of oil-well perforating pioneered by the Byron Jackson Company. He has been in charge of this work for the last three years. Box was graduated from the University of Santa Clara with a degree in mechanical engineering.

William T. Box

Matthew A. Taylor, assistant manager of Eastern sales region, has been named manager of sales operations, Ethyl Corporation. Other promotions include: **Donald S. Flynn** and **George P. Rosser,** account representatives, have been named assistant managers of the Eastern region, with Flynn in New York, and Rosser in Pittsburgh.

William K. McCulloch, sales promotion manager, was promoted to assistant manager of the advertising and sales promotion department, and **Donald J. Chapman,** account representative in the Western region, to sales promotion manager.

Under the re-organization of the advertising and sales promotion department, **Frank A. Howard, Jr.,** will be in charge of advertising, and **Edwin J. Enoch, Jr.,** will continue to be in charge of advertising and sales promotion production.

Also announced is creation of district managerships, in place of resident managerships, throughout the four sales regions. District managers are: Eastern region: **Roy L. Goltz,** New York City; **Robert W. Richardson,** Philadelphia. Central region: **Harry A. Mack,** Dayton; **George W. Rose,** Chicago; **Robert R. Mead,** Kansas City, Missouri; Southern region: **Leonard L. Huxtable,** Tulsa; **Russell Schell,** Dallas; **J. O. Balzer,** Houston; **Alan C. Tully,** Baton Rouge. Western region: **Monroe F. Weill,** Los Angeles; **William H. Sievert,** San Francisco; **John S. Cole,** Salt Lake City. In addition, **Gelston Howell,** account representative in Western Pennsylvania, has been transferred to the New York office of the Eastern region.

Karl V. Rohlen has been named president of Crane Packing Company, and **Frank E. Payne,** former president, has been elected chairman of the board, upon retirement of A. W. **Payne,** chairman of the board. Rohlen was former vice president and general manager. F. E. Payne founded the company in 1916 and since that time has been active in the business. Rohlen, a University of Illinois graduate, joined Crane in 1942.

Karl V. Rohlen

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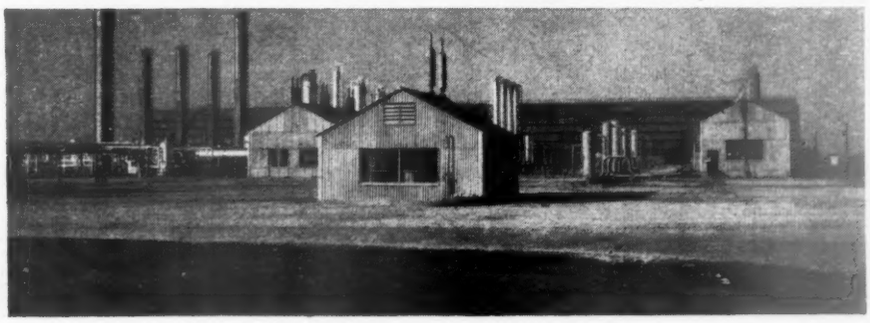

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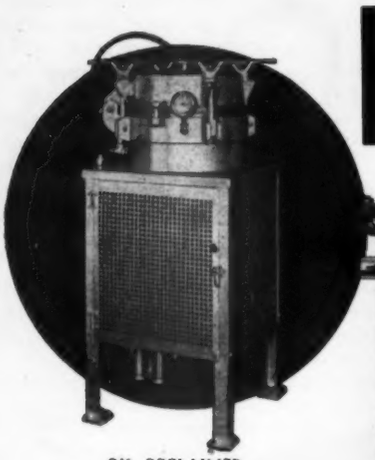

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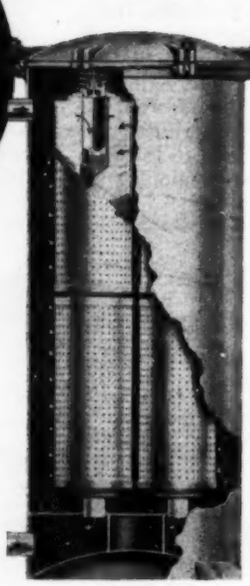

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Trade Personals

D. D. Walters

Charles Simmons

D. D. Walters has been promoted to manager, north Permian Basin district for The Western Company. Other promotions include: **Charles Simmons,** to assistant manager, north Permian district; **Henry Landusky,** to manager, Snyder station; **Jim Wilson,** to assistant manager, Hobbs station; **J. D. Allen,** to assistant manager, Seagraves station, and **Roy S. Priolo,** to assistant manager, Levelland station. Walters has been with The Western Company for four years and formerly was manager of the Eunice station. Simmons has been with Western for three years.

G. J. Van Dyke has been appointed district service manager at Pharr, Texas, for Cummins Sales and Service, Inc. Van Dyke began his career with Cummins in 1945 as shop mechanic. He was subsequently promoted to field serviceman at Odessa, Texas, then to shop foreman at the same location.

E. G. Ellis has been promoted from general service manager to vice president-maintenance and engineering, and **J. L. Peeler,** former assistant purchasing agent at Fort Worth, Texas, appointed to director of purchases at the same location, by Cummins Sales and Service. Ellis was formerly export service manager with Mid-Continent Cummins Export Corporation in New York City.

Peeler formerly worked for Mid-Continent Supply Company.

Lee Grumbaugh has been named sales development engineer in the petroleum industry for Kennametal, Inc., Latrobe, Pennsylvania. Grumbaugh began in the petroleum industry 25 years ago. He has since been an oil operator, specializing in well rehabilitation, at Signal Hill, California, and more recently operated his own steel and pipe supply company in Colombia, South America.

Lee Grumbaugh

Herbert B. Hummer has been appointed director of research for the Durametallic Corporation of Kalamazoo, Michigan. He was formerly with the Allis-Chalmers Manufacturing Company, Norwood, Ohio.

William A. Johnson has been promoted from president to chairman of the board, of Amercoat Corporation, South Gate, California. **Alan E. Turner,** former executive vice president, is the new president.

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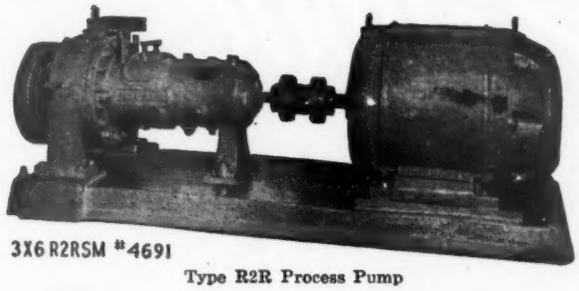
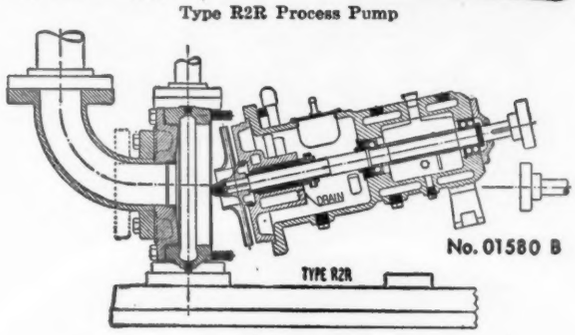


Type R2R Process Pump



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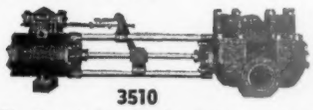
DISASSEMBLY: The Type R2R process pumps can be disassembled without disconnecting the suction and discharge piping. By first removing the spacer from the spacer type coupling, and unbolting the casing from the cradle the entire cradle and complete rotating element can be removed without disturbing the suction and discharge piping.

OPERATING RANGE: Type R2R, Heavy duty, process pumps are available in eighteen different sizes, enabling our engineers to furnish units specially designed and constructed for the particular work to be performed.
Capacities: 50 to 2000 Gallons per minute.
Heads: Up to 400'. Speeds: 900 RPM to 4000 RPM.

BUILDERS OF OUTSTANDING PUMPS SINCE 1869

CENTRIFUGAL AND RECIPROCATING PUMPS

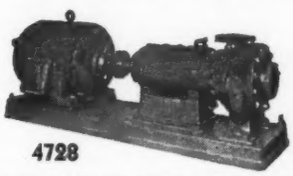
Close Coupled Centrifugal Pump



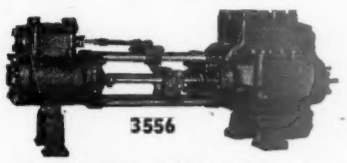
Horizontal, Single Style, Double Acting, Piston Type, Close Clearance Pump. Designed to handle volatile liquids

Pedestal Mounted Centrifugal Pump

Horizontal, Duplex, Double Acting, Side Pot, Piston Type, Oil Bath Power Pump



Double Pedestal Bearing Centrifugal Pump



Durable Duplex Packed Piston Pattern Steam Pump, Side Pot Type

ESTABLISHED 1869

DEAN BROTHERS PUMPS INC.

INDIANAPOLIS IND.

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Trade Personals

Al K. Kline

▸ **Al K. Kline** has been named Western representative of Larkin and Company, Inc. Kline was formerly with Calco Oil Tools, Tulsa, Oklahoma, and Baker Oil Tools. He will be in charge of Larkin's new office and warehouse facilities in Tulsa.

▸ **Calvin B. Carter** has been promoted to assistant sales manager and **R. Carson Allan** to division engineer, National Supply Company. Carter joined the company following his graduation from the University of Texas in 1937. He was made division engineer for the export division in New York in 1947. Allan joined the company following graduation from the University of Michigan in 1938.

▸ **I. W. McKinney** has been appointed manager of the newly formed C-R-C supply division, Crutcher-Rolfs-Cummings, Inc. Before joining C-R-C McKinney was in the valve division of Cameron Iron Works, Inc. He was formerly a field engineer and metal inspector for Humble Oil and Refining Company at Baytown and a pipe line engineer for Humble Pipeline Company.

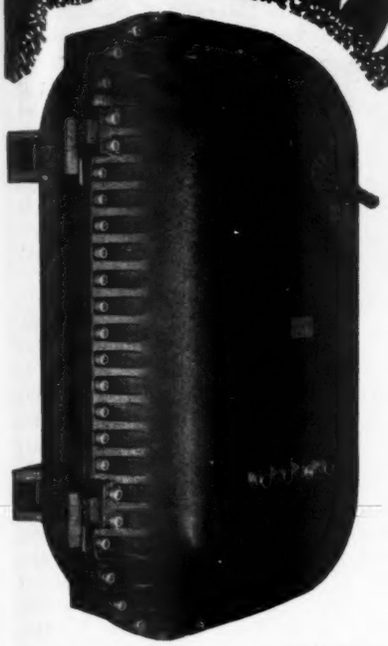
I. W. McKinney

▸ **Fred C. Schulz, Don W. Gates,** and **Grover C. Clark** have moved to new assignments with The B. F. Goodrich Company's Associated Tire and Accessories Division. Schulz has become Pacific Coast manager for the division succeeding K. K. Kantzer, who died recently. For the past 2½ years Schulz had been manager of sales development for BFG's Associated Lines with headquarters at Akron. He was graduated from Ohio State University. Gates has been appointed merchandising manager. With BFG since 1939, he went to Akron in 1942 to assume sales promotion duties. Clark becomes manager of advertising and sales promotion for Associated Lines succeeding Gates.

▸ **John R. Rowe** has been added to the staff of the Electric Machinery Manufacturing Company Dallas office. He will assist **H. L. Renking,** E-M Dallas district manager. Rowe is a graduate of the University of Wisconsin in electrical engineering, and holds a master's degree from the Harvard University graduate school of business administration.

John R. Rowe

Now! A SIZE 5 EXPLOSION-PROOF STARTER with AIR CIRCUIT BREAKER



The "NEMCO" Size 5 Explosion-Proof Combination Motor Starter with Air Circuit Breaker — — for use in Class 1, Group D Hazardous Locations. "Start-stop" control station and reset buttons are mounted in cover.

The "NEMCO" Size 5 Explosion-Proof Combination Motor Starter is probably the only starter of its size and type to be manufactured in the combination air-break form.

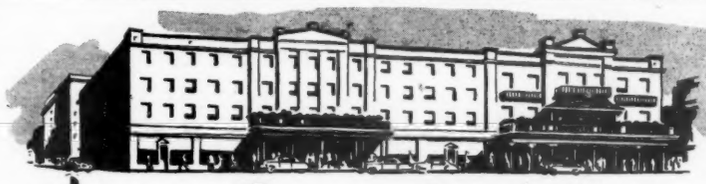
Desirable features include: Rugged enclosure of gray iron; ground flange surfaces; heavy pin-type hinges; available with control stations or pilot lights in cover; can be furnished with sealing hoods for conduits. Interior has ample space for incoming and outgoing leads as well as for auxiliary relays, control transformers, etc.

The size 5 starter unit, air circuit breaker and all other components are the finest that money can buy.

WRITE FOR COMPLETE INFORMATION

NELSON *Electric* MANUFACTURING CO.

217 North Detroit TULSA, OKLAHOMA Telephone 2-5131



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HOTEL CLAYPOOL	Indianapolis
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JUNG HOTEL	New Orleans
HOTEL DESOTO	New Orleans
NEBRASKA	
HOTEL PAXTON	Omaha
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HOTEL CLOVIS	Clovis
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TEXAS	
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HOTEL BAKER	Dallas
HOTEL TRAVIS	Dallas
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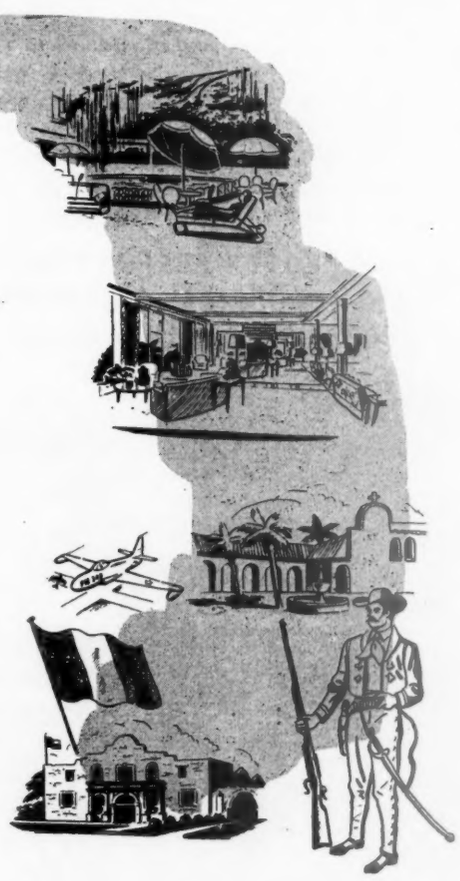
HOTEL BUCCANEER	Galveston
HOTEL GALVEZ	Galveston
HOTEL JEAN LAFITTE	Galveston
CORONADO COURTS	Galveston
MIRAMAR COURT	Galveston
HOTEL PLAZA	Laredo
HOTEL LUBBOCK	Lubbock
HOTEL FALLS	Marlin
HOTEL CACTUS	San Angelo
HOTEL MENGER	San Antonio
ANGELES COURTS	San Antonio
VIRGINIA	
HOTEL MOUNTAIN LAKE	Mountain Lake
HOTEL MONTICELLO	Norfolk



AFFILIATED NATIONAL HOTELS

Trade Personals

Hubert C. Laird, until recently vice president of Otis Engineering Corporation, has joined Crane Company as field engineer to expand the company's services to the petroleum industry. Laird will concentrate on the valve and fitting problems of petroleum production. He will work from the engineering division headquarters at the Crane Chicago plant. He is a graduate of Oklahoma A and M where he received his engineering degree in 1933.

Hubert C. Laird

Dr. C. M. Blair has been named superintendent of the new plastic and resins plant to be constructed at Seadrift, Texas, by Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation.

John Conway, J. A. Field, and **W. A. Woodcock** have been named assistant managers to Dr. R. L. Bateman, manager of the company's fine chemicals division.

R. F. Brown was appointed assistant sales manager in the company's industrial chemicals division. He is being replaced as midwestern division manager with headquarters in Chicago by **R. M. Joslin, Jr.,** district manager of the Philadelphia area.

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Double Duty

in OIL FIELDS!

SHALE SEPARATOR & SAMPLE MACHINE

Thompson does a double duty job and does it better: (1) by removing destructive shale and abrasives from your drilling mud, it saves you money because unnecessary wear and tear on costly drilling equipment is reduced to a minimum, and (2) the Sample Machine (standard equipment) gives an accurate analysis of the progress of the well by collecting foot-by-foot cuttings. Thompson Separators are self-motivated, activated by the mud flow. Make Thompson a part of your standard drilling equipment.

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★ ECONOMICAL OPERATION
★ SAVES DRILLING COSTS

Thompson TOOL CO.
IOWA PARK, TEXAS

R. E. "Ernie" Haskell, Canadian geologist, has been named service engineer in charge of radiation well logging in Canada, of McCullough Tool Company. Haskell will operate out of the McCullough divisional headquarters at Edmonton, Alberta.

R. E. Haskell

Haskell holds a BS degree in geology from the University of Manitoba. He has arrived in Canada with a new special logging truck, completely equipped for gamma ray and neutron logging and necessary equipment for on-the-spot interpretation.

W. C. Watson of the oil field sales division of Cameron Iron Works, Houston, Texas, has been transferred to the valve sales division. Watson's headquarters will be in Odessa, Texas. He will handle valve sales in West Texas and Western United States.

J. S. Caffrey has been named fleet supervisor of The Western Company. In his new capacity, he will assist J. L. Myers, assistant vice president, in the development and administration of policies in regard to the company's automotive fleet. He will also supervise the assignment and maintenance of all company cars. Caffrey has been with The Western Company since 1944.

J. S. Caffrey

R. S. Stevenson was elected executive vice president of the Allis-Chalmers Manufacturing Company by the board of directors recently. Before he was elected to this company-wide post, Stevenson was vice president in charge of the tractor division. **Willis G. Scholl,** formerly vice president and general sales manager of the tractor divsion, was elected to succeed Stevenson. Named to succeed Scholl as vice president and general sales manager was **Frank Mussell,** eastern territory manager of the tractor division.

J. A. McCreery has been named manager of Continental Supply Company's Elk City, Oklahoma, store. He was formerly field salesman at the same location. **E. D. Lawrence** has been transferred to the New Orleans district office where he will serve as sales representative, going from field salesman at Lake Charles. New manager of the McAllen, Texas, store is **Sidney G. Pierce,** formerly floorman at Alice, Texas.

Karl D. Jahnke has been appointed credit manager and elected assistant secretary-treasurer of Dodge Manufacturing Corporation. Previous to joining Dodge, Jahnke spent six years with the accounting firm of Ernst and Ernst. He is a certified public accountant.

BOOKS

The Measurement and Control of Temperatures in Industry. *by R. Royds. Published by Chemical Publishing Company, Inc., 212 Fifth Avenue, New York 10, N. Y. Price, $5. Pages, 252.*

The latest developments in temperature measurement and control to help industries to maintain the highest possible thermal efficiency are covered in this book. The various methods and equipment available for the measurement of temperatures in each particular range are discussed. Standardization and automatic control of temperatures are discussed at length. One hundred and sixteen illustrations, tables and numerous equations for calculating results are contained. Attention is given to improving the quality and reliability of industrial products, an increased rate of production, and the saving of fuel and labor by the application of automatic temperature controls. The information is slanted toward the metal, chemical, petroleum, glass and refractory, cement, and various other industries.

Chemical Engineering Operations, *by F. Rumford. Published by Chemical Publishing Company, 212 Fifth Avenue, New York 10, N. Y. Price, $7.50. Pages, 371.*

The basic principles of the operation of chemical plants are related in this book. It discusses the most important processes used in chemical industries and describes the principal types of apparatus for carrying out each process. Theoretical aspects of chemical works procedures are covered and their mathematical foundations given. Processes and equipment are evaluated from the viewpoint of efficiency and economy, and illustrative examples are listed for every operation treated, including calculations of results and graphical presentation. The book contains over 200 illustrations that will be helpful to the chemical technologist and engineer — particularly the beginner and student.

Numerical Methods in Engineering, *by Mario Salvadori. Published by Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price, $6.65. Pages, 251.*

This book presents a simple discussion of numerical methods used to solve problems arising in all branches of applied science. It is designed for a one-semester course offered to upperclass students who have studied calculus and elementary differential equations. The treatment is based essentially on the use of finite differences. Differentiation, integration, interpolation, extrapolation, and integration of differential equations are united by this approach. Relaxation methods are presented in detail and are applied to a variety of physical problems.

Properties of the Principal Fats, Fatty Oils, Waxes, Fatty Acids and their Salts, *by M. P. Doss. The Texas Company, 135 E. 42nd St., New York, N. Y. Price, $5. Pages, 244.*

This new book should be of interest to the fatty oil, petroleum, and chemical industries, and especially to manufacturers of lubricants. In its pages the new publication covers the properties of approximately 50 of the principal fats, fatty oils, and waxes. Only aliphatic acids are discussed but the properties of more than 800 of these are tabulated. Data are given on the salts of the fatty acids ranging from aluminum through zirconium. Approximately 1750 salts are listed. This material has never previously been brought together and it includes considerable unpublished data.

Annual Review of California Crude Oil Production, *published by the Conservation Committee of California Oil Producers, 855 Subway Terminal Building, Los Angeles 13, California.*

This annual report covers the activities of the Conservation Committee and statistical information relative to crude oil production in California. The book is divided into sections which take in historical data, statistics on conservation, oil development and new completions, fields and pools, and number of wells. A general summary of the year is also given. The book provides a valuable reference of crude oil production in California.

It helps to have the Right Answers!

High temperature, high pressure Piping Installations required in modern power plants make it imperative to carefully calculate the loads they will carry and the supports required. *All* of the problems involved can be solved by correctly allocating

BLAW-KNOX PIPE HANGERS

and Vibration Eliminators in accordance with data made available by the Power Piping Division. Many hours of "spec" time can be saved by reference to the Blaw-Knox line of *standardized* hangers and assemblies, together with Flex-Anal Charts for further guidance . . . as any engineer (or schoolboy) will tell you—"It helps to have the right answers."

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Power Piping & Sprinkler Division
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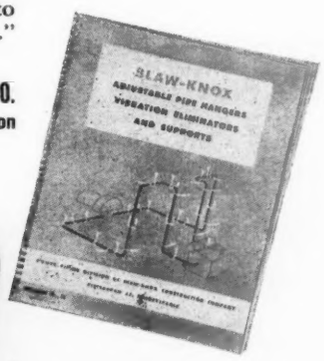

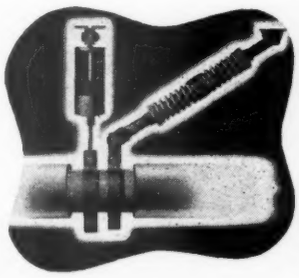

CATALOG NO. 51 is of equal value whether you are planning a new piping installation or wish to correct the faults of an existing one. Please request it on your letterhead.

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Make a 90-day test of the formula your Visco Service Man recommends. Odds are high — from actual count — that once you see Visco results, you will not be without your Visco formula, or the twenty-four-hour-a-day Service that goes with it.

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New Machinery and Supplies

Use reply card to procure promptly complete information and prices of products described here in brief.

Circle corresponding letter or letters on reply card

(A) EXPANSION JOINTS

Flexonics Corporation, formerly Chicago Metal Hose Corporation, announces significant design improvements in its Flexon expansion joints, and the addition of a 3-in. size to the general line. New Flexon expansion joints in both controlled and free-flexing types offer greater pipe line motion control with less overall expansion joint dimension required to handle a given amount of pipe line expansion.

Circle letter (A) on reply card.

(B) TRANSMITTER

A new desk-mounting FM transmitter and receiver has been developed by the engineering products department of RCA Victor for public safety and industrial mobile radio systems operating in the 152-174 megacycle frequency band. Combining a 60-watt transmitter, a highly selective adjacent-channel receiver, operating controls, and a power supply, this new "Carfone" unit is a complete headquarters radio station. The new desk station is equipped to transmit on three frequencies and receive on two frequencies, making possible multichannel operation.

Circle letter (B) on reply card.

(C) TORQUE CONVERTER

The Unit Crane and Shovel Corporation is announcing the application of fluid torque drive as a standard installation on its ½-yard crawler and mobile machines. The torque converter in mobile equipment allows for smooth breakaway performance. The fact that it is connected to a worm-driven power take-off by means of a chain coupling eliminates the engine clutch and its lever system.

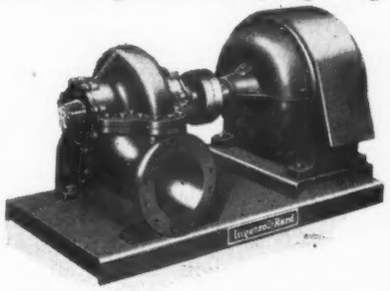
Circle letter (C) on reply card.

(D) SIGNALING UNIT

The Hammarlund Manufacturing Company has announced the introduction of a new duplex signaling unit consisting of a tone transmitter and frequency selective receiver designed to operate over wire lines, telephone or power line carrier, and radio or microwave communications circuits. The units may be used to transmit and receive signaling, dialing, telemetering, teleprinting, supervisory controls or other information. Transmitters and receivers are available on the same or different frequencies between 2000 and 6025 cycles per second.

(E) PUMPS

Ingersoll-Rand Company announces further advanced design improvements in its existing line of small, single-stage,



double-suction pumps. These pumps, known as the Class DMV-DHV, are the first to incorporate double mechanical shaft seals with sealed, pre-lubricated ball bearings. Built in 3, 4, 5, and 6-in. sizes, the DMV (for medium heads) and the DHV (for high heads) are designed for general hydraulic services at temperatures up to 200 F, capacities to 2100 gpm and pressures to 150 psi. The use of a double shaft-seal affords the advantages of more efficient sealing and prevents air leakage into the pump when it is operating under suction lift.

Circle letter (E) on reply card.

(F) POWER UNITS

Compact, space-conserving J. I. C. power units are now manufactured by Superdraulic Corporation in 30, 60 and 80-gal standard sizes. These new units are assembled with Superdraulic or any other make pump specified by the customer. In addition to pump, motor, valving, etc., the Superdraulic design features such details as ample floor clearance, large tank cleanouts in both ends.

Circle letter (F) on reply card.

(G) WELLCHECKER

A new horizontal wellchecker has been developed by the Oil Metering and Processing Equipment Corporation, a company recently formed for the production of wellcheckers and metering units for oil-producing companies. An outstanding feature of the new wellchecker is a degassing and defoaming element placed on the inlet nozzle just inside the separator so that all of the well fluid must flow through it. This element removes all of the gas from the oil that is not in solution in the oil and as it also prevents foam, the oil is in good condition to be metered and thus accurate results are obtained.

Circle letter (G) on reply card.

Wellchecker developed by Oil Metering and Processing Equipment.

(H) TUBING HEAD

Alten Foundry and Machine Works, Inc., has announced a new threadless stubby tubing head. Similar in construction to Alten's threaded stubby, this new head is made to meet the demand for a threadless, slipover type. It packs on tubing or coupling and is available as split or solid gland. Its squatty design brings well-head equipment low.

Circle letter (H) on reply card.

(I) PIPE FITTINGS

Yardley Plastics Company pipe and fittings produced of tough Tenite plastic, a product of Tennessee Eastman Company, make possible rapid laying of pipe lines in oil-field and industrial systems. The fittings are injection molded in a variety of sizes and shapes, either slip-sleeve or threaded, to fit extruded pipe with diameters up to 6 in. Slip-sleeve couplings can be quickly and permanently bonded into Tenite lines by means of a cement and thinner, which have an affinity for the plastic. Lightweight and high in impact strength, pipe and fittings of Tenite simplify handling and installation problems.

Circle letter (I) on reply card.

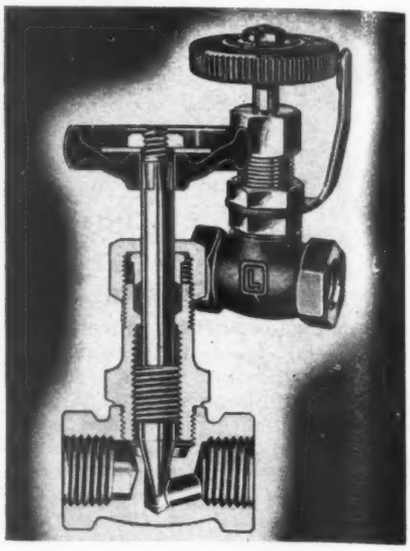
(J) OSCILLATOR

A new low frequency oscillator, designed as a source of signal power in the range of .01 to 100 cps, has been announced by the Southwestern Industrial Electronics Company. The oscillator features the use of passive elements (resistors and condensers) for frequency determination; and, therefore, offers excellent short- and long-time frequency stability. The circuit has been treated as a DC amplifier, and both plate and filament supplies have been carefully regulated. The output circuit is directly coupled to the load and will produce 20 v or 20 ma into any load impedance. Two means of control are given.

Circle letter (J) on reply card.

(K) NEEDLE VALVE

Introduction of a new gland-type bronze needle valve has been announced by The Lunkenheimer Company. The new valve is small and compact, making it ideal for use in pin-point control on small lines where fine regulation of flow is essential. It is manufactured in a full range of sizes from ⅛ in. to 1 in., in both globe and angle patterns.



Circle letter (K) on reply card.

(L) STEEL TAPE

Lufkin Rule Company has introduced a new "Royal" Ni-Clad steel tape. Figures and graduations will not wear off, as they are an integral part of the steel. The hard nickel-plated surface makes the line rust and corrosion resistant, Lufkin reports. Hook ring is provided on this tape at no extra charge. Folding flush handle opens with push pin.

Circle letter (L) on reply card.

(M) WELDED GRATING

The Klemp Metal Grating Corporation has produced a new open steel welded grating called "Klemp-Krest." The new Klemp-Krest welded grating features round steel cross bars so formed as to provide a peak, or crest, on the top side of the bar. These bars are placed at right angles on top of flat bearing bars set on edge and then electro-welded under great pressure.

Circle letter (M) on reply card.

(N) WORM GEAR

The American Car and Foundry Company valve division has announced the use of Cone-Drive double enveloping worm gearing on many of their larger size lubricated plug valves, both in semi-steel and in carbon steel. These gears are made by Cone-Drive Gears Division, Michigan Tool Company, and were selected for their high-load carrying capacity and compact design; the gears are enclosed in a specially designed sealed housing that is filled with lubricant. These gears are standard on the ACF 400-lb class, carbon steel valves with full round opening ports in size 4, 6, and 8-in.

Circle letter (N) on reply card.

This Plant Claims Their

HEAT SAVINGS PAID for NICHOLSON TRAPS

Nicholson expansion steam traps were installed by a processor on tank heaters and coils where various unit temperatures from 160° to 185°F had to be maintained. The steam temperature was 320°F. Figuring the difference in heat loss between Nicholson traps discharging condensate at 160° and others discharging it at about steam temperature, they feel heat loss was cut nearly in half. Due to their effectiveness in controlling temperature as well as draining condensate, Nicholson traps are paying for themselves in many industries.

FOR ALL EQUIPMENT USING STEAM OR HOT WATER

CATALOG 751 OR SEE SWEET'S

Absorption Stills, Agitators, Evaporators, Gas Holders, Heat Exchangers, Heavy Oil Tanks, Kettles, Petroleum Tanks, Pipe Coils, Radiators, Reboilers, Steam Stills, Tar Tanks, Wax Tanks

217 Oregon St., Wilkes-Barre, Pa.

W. H. NICHOLSON & CO.

TRAPS · VALVES · FLOATS

(O) GAS BURNER

Research Vacuum Supply Company is introducing a special type of gas burners. These NS type of fishtail burners have been developed for localities where natural gas has replaced manufactured gas. Natural gas being of the slow-burning variety requires a greater percentage of air in the mixture. The additional channels are provided in the design of the NS burners to allow the required air flow to give desired burning qualities.

Circle letter (O) on reply card.

(P) PROTECTIVE COATINGS

The Ric-wiL Plastic Coating and Manufacturing Corporation has entered the field of "protective coatings for industry" with its line of "Ricwilite" phenolic resin coatings. Ricwilite coatings are specially formulated to protect equipment against extremely corrosive conditions in all types of industry with a tough, impervious film, which is resistant to attack by corrosive acids and alkalis, salt water, rust, and weathering.

Circle letter (P) on reply card.

(Q) CONSISTOMETER

The new Cenco-Bostwick consistometer is designed to measure the consistency of viscous materials by timing the flow over a measured course. The Cenco-Bostwick consistometer is constructed of a graduated, rectangular, monel-metal trough divided about two inches from one end into two sections by a vertical-action gate. The gate is spring operated and held down by an L-shaped trigger, which releases it instantaneously. The larger section of the trough is graduated on the bottom in divisions of 0.5 cm.

Circle letter (Q) on reply card.

(R) PIPE TAPE

Dressertape, the new polyvinyl chloride pipe tape recently offered by Dresser Manufacturing Division, is now available in one inch width in addition to the two inch previously sold. The one inch tape is particularly adaptable for wrapping fittings. Possessing insulation resistance of 100,000 megohms and dielectric strength of 10,000 volts, 10-mil Dressertape offers protection against water, salt water, acids, alkalies, oil and soil chemicals.

Circle letter (R) on reply card.

(S) PEST CONTROL

Plans for the large-scale production of lindane, an insecticide, are announced by Ethyl Corporation. A new plant being built by Ethyl, and scheduled for completion early next year, "will make lindane available for many crops heretofore limited to older insecticides as well as to open up broad new applications in effective pest control."

Lindane is reported to be highly effective against a wide range of insect pests, and can safely be used, under prescribed conditions on livestock and food crops as well as on fiber and forage crops. Lindane can be applied as a dust or a vapor, a spray or an aerosol, and in the form of a salve.

Circle letter (S) on reply card.

(T) LIQUID METER

The Weigh-O-Matic liquid meter, designed and manufactured by Oil Field Material Equipment Company, Houston,

Texas, provides a simple and accurate means of measuring liquids. The Weigh-O-Matic meter weighs liquids continuously in small "batches" and totals the number of these "batches" on a mechanical counter. By knowing the given weight held by each compartment of the meter, which in turn represents a given volume of liquid, the volume of liquid passing through the meter can be easily determined. All Weigh-O-Matic meters operate at atmospheric pressure. The meter is available in ⅛, ¼, ½ and 1 barrel per dump sizes in each of three different models.

Circle letter (T) on reply card.

(U) PILLOW BLOCKS

A new line of all-steel pillow blocks, providing high load-carrying capacity in a compact and rugged package, has just been announced by the Dodge Manufacturing Corporation. These new bearings are announced as a joint achievement by Dodge and the Timken Roller Bearing Company, the result of pooling the engineering resources and bearing building experience of both companies. The bearings are fully self-aligning, with spherical outer race. They are available in both expansion and non-expansion types.

Circle letter (U) on reply card.

(V) AUTOMATIC WIRE

The Mir-O-Col Alloy Company, Inc., has placed on the market a new low-cost "Mir-O-Col 45-90 Method" for rebuilding tractor and shovel rollers, idlers, and rails. The new Mir-O-Col 45-90 method, states the company, will enable users to cut tractor and shovel roller, rail, and idler rebuilding costs. Mir-O-Col No. 45 automatic wire has a high nickel content to withstand heavy impact and can be used in multiple-pass operations with no stalling. Hardness of deposit is from 22 to 28 Rockwell C.

Circle letter (V) on reply card.

POWER TO FIT THE MACHINE
POWER TO FIT THE JOB

WISCONSIN-Powered Pump

Whether small or large, pumps are vitally important in pumping oil or drilling for it. That's why so many Wisconsin Heavy-Duty Air-Cooled Engines get the power assignment, from the smallest 3 hp. single-cylinder unit on up to the largest 30 hp. 4-cylinder models. This Wisconsin-powered Construction Machinery Corporation pump is typical.

Many oil men know, and more new users are finding out daily that Wisconsin Engines deliver the goods. Timken tapered roller bearings at both ends of the crankshaft take up all thrusts. Fool-proof air-cooling maintains efficient operating temperatures, summer and winter. And an easily-serviced OUTSIDE magneto with impulse coupling delivers the quickest all-weather starts. Backing up these great features is heavy-duty construction . . . your assurance of the best performance from these features, *initially* and over the *longest period of time.*

4-cycle single-cylinder, 2-cylinder and V-type 4-cylinder models, 3 to 30 hp.

WISCONSIN MOTOR Corporation
MILWAUKEE 46, WISCONSIN
World's Largest Builders of Heavy-Duty Air-Cooled Engines

WRITE TO HARLEY SALES CO.
619 S. MAIN STREET, TULSA, OKLAHOMA
M & M BUILDING, HOUSTON, TEXAS
505 SOUTH MAIN ST., WICHITA, KANSAS
OIL FIELD DISTRIBUTORS FOR WISCONSIN ENGINES AND ALL TYPES OF UTILITY UNITS.

A 7254-3½

(W) FLOWMETER

Accurate measurement of flow of liquids and gas under difficult conditions is made possible by the development of a new, improved flowmeter. The new unit is capable of handling toxic or highly corrosive substances, viscous liquids or other fluids under pressures up to 20,000 psi and temperatures ranging from – 269 C to 1200 F. The instrument, recently improved in cooperation with Minneapolis-Honeywell's Industrial Division, permits all parts, except the sensing element, to be encased in a Brown ElectroniK potentiometer. The device is being marketed as the Potter-Brown flowmeter.

Circle letter (W) on reply card.

(X) GAS, OIL BURNER

Fireye Programming Control Type 26RJ8 is designed to provide automatic starting and control for commercial and industrial gas, oil, and combination gas/oil burner equipment. It is used with the new Firetron Scanner Type 48PT1 to protect burner installations from the hazard of flame failure. The control automatically starts a burner in operation and programs a sequence of pre-purge, ignition-on, fuel valve delay, post-ignition timing, and post-purge. Programming Control Type 26RJ8 incorporates many unique design features. Its instantaneous response to flame failure results in fuel cut-off in seconds.

Circle letter (X) on reply card.

(Y) FLEXIBLE VALVE SHIELD

A new flexible valve shield made of neoprene synthetic rubber has been introduced by Du Pont for use on valves handling acids and other hazardous chemicals. The shield protects the operator from injury if the valve stem packing should fail; it cups the stem and the packing gland and prevents acid from spraying on the operator or anyone working close by.

A major advantage of the shield is its flexibility. It can be turned back to inspect the valve or to tighten the packing gland nuts. Since it need not be removed, there is no risk that it will not be replaced.

Circle letter (Y) on reply card.

(Z) TELESCOPING ANCHOR

MWL Tool Company announces a tool offering a new concept for packer seating . . . because it insures a first trip seat every time. With the ability to telescope to any point within a range of 15 ft this new tool presents any number of packer points within the tool's telescoping range without round tripping the tubing. All that is required to respace the packer is to pick up the tubing the desired distance and the telescoping anchor will extend itself to hold the weight of the tubing at that point.

Circle letter (Z) on reply card.

(AA) GAS BURNER

The design of this burner is simple, sturdy and easy to install. Each section has two radiating armed spiders. Each spider has an individual mixer, all air for combustion is taken through the burners. The mixers aspirate a sufficient quantity of primary air to always insure a short flame. John Zink Company makes the burner.

Circle letter (AA) on reply card.

(AB) HARD FACING ELECTRODE

A low priced hard facing electrode giving a deposit material consisting of chrome, manganese, silicon, iron alloy is announced by Wall Colmonoy Corporation. This deposit has very good abrasion and shock resistance and has stainless qualities approximately equivalent to type 410 stainless steel. The deposit of this electrode has a hardness ranging from 49 to 53 Rockwell C.

Circle letter (AB) on reply card.

(AC) BALL JOINTS

Fireproof, all steel, flexible ball joints suitable for use on working pressures up to 7500 psi (hydraulic) are offered by Barco Manufacturing Company of Chicago. Produced in steel and alloy steel, the design differs somewhat from lower pressure joints in that the inner seal on the ball is a free-floating part carried under constant spring pressure. This insures positive, leakproof sealing at low or zero pressure and also makes the joint easy to turn and move. All steel construction and metal seals provide complete protection against fire.

Circle letter (AC) on reply card.

When it is necessary to move from an old lease don't leave your investment in housing behind. Leave no ghost town of crumbling houses and buildings.

Use STURDYBILT Prefabricated, *Movable* houses. Then you can take your investment in housing with you to an active location.

Investigate STURDYBILT Prefabricated buildings before you buy *any* oil field housing.

Manufacturers of Special Millwork
Distributors of Johns-Manville Building Materials
Curtis Woodwork

STURDYBILT PREFABRICATED, DEMOUNTABLE HOUSES

SOUTHERN MILL & MANUFACTURING CO. • TULSA, OKLAHOMA

STURDYBILT HOUSES COMPLY WITH COMMERCIAL STANDARD CS125 OF THE NATIONAL BUREAU OF STANDARDS FOR PREFABRICATED HOMES

Trade Literature

Publication will be sent free.

(AD) PIPE AND FITTINGS

Three descriptive and technical bulletins on the subject of acid-proof materials and construction are offered by Aqua-Therm, Inc. Bulletin No. 139 discusses Eonite pipe and fittings, made of furan resin material reinforced with laminations of chemical glass fabric cloth, for handling most mineral acids, alkalis, and organic solvents. Bulletin No. 160 discusses the acid-proof construction of pickling and plating tanks; process tanks, vessels, and towers; pickling and plating basins, acid proof floors. Bulletin No. 190 discusses Eonite lacquer, a coating to protect interior or exterior surfaces from the corrosive effects of gases, vapors, mists, and liquids.

Circle letter (AD) on reply card.

(AE) PUMP APPLICATIONS

A new type of reference chart on small pump applications has just been developed by Tuthill Pump Company, Chicago. In one table (letterhead size), this guide lists the various types of Tuthill pumps, the services for which each is built, the performance characteristics, types of packing, styles of mounting, and features that distinguish each model. Thus, selection of the proper pump for the purpose is simplified, it is stated.

Circle letter (AE) on reply card.

(AF) TRUCK-MOUNTED CRANE

A new and profusely illustrated 4-page folder featuring on-the-job applications of the truck-mounted Bantam is being released by the Schield Bantam Company. The new folder presents actual job applications and production records of Bantam owners, with illustrations of their machines in operation. The variety of job records contained in this folder illustrates the versatility of the Bantam.

Circle letter (AF) on reply card.

(AG) TUBE EXCHANGER

Griscom-Russell Company has just published a bulletin on a finned tube heat exchanger with a particularly wide application for heating and cooling liquids and gases, and for condensing vapors. The bulletin fully describes this exchanger, known as the G-R Twin G-Fin section, and explains the features of its design and construction that have proved to give highly effective service in installations totaling more than 70,000 sections.

Circle letter (AG) on reply card.

(AH) PAPER TUBING

Recently published, a new arbor list of more than 1500 sizes is now available from the Precision Paper Tube Company. This 16-page catalog listing contains informative data and specifications on square, rectangular, and round tubing. Listed under small machine tube arbors are rectangular and square tubes of ¼-in. diameter and under, length to 12 in., with wall thicknesses from .006 to .020 in. Standard and large square and rectangular tubes are listed under automatic tube arbors.

Circle letter (AH) on reply card.

(AI) PRESSURE FILTER

Graver Water Conditioning Company has just published a bulletin on pressure type filters for the removal of visible suspended matter from water. The bulletin describes the details of design and construction of these units, which are built in both vertical and horizontal types, together with all the accessory equipment provided to help promote maximum efficiency.

Circle letter (AI) on reply card.

(AJ) SPLASHPROOF MOTORS

The Elliott Company has published a new four-page illustrated bulletin describing its complete line of outdoor splashproof (weather protected) fabristeel induction motors ranging in size from 250-4000 hp, 2 poles; 50-?000 hp, 4 to 14 poles. The bulletin includes an explanation of the Elliott ventilation system, which culminates five years of pioneering in outdoor motor design. Simplified Elliott fabricated steel construction and improved design features are fully described and illustrated.

Circle letter (AJ) on reply card.

(AK) GAGE TYPES

Jerguson Gage and Valve Company has announced a new 4-page bulletin on its various gage types. Each type is pictured, and thoroughly described. Such developments as heated and cooled gages, non-frosting gages, flanged-end gages, etched-glass gages, reaction chambers gages, and gages of special metals, are claimed by the company. Also described are various types of process gages, gage valves, accessories, special application gages, steam gages, and mercury vapor illuminator for steam gages.

Circle letter (AK) on reply card.

(AL) CAUSTIC SODA

Dow Chemical Company has published a newly revised booklet covering all phases of caustic soda. The booklet specifically deals with: Manufacture of caustic soda, chemical and physical properties, economics involved, methods of handling and storing; technical properties, methods of analysis, and first-aid treatment for caustic burns.

Circle letter (AL) on reply card.

(AM) SPREADER

A new catalog describing the many features of the recently introduced Buckeye Model 5 spreader has been announced by Gar Wood Industries, Inc. Some of the design and construction features highlighted are the controlled volume and rate of spread. The rate of spread is uniform regardless of the truck speed as the feed roll is powered from the spreader wheels. Feed roll can be adjusted to permit a tapered spread of material.

Circle letter (AM) on reply card.

(AN) pH CONTROL

Once confined to laboratory use and batch processes, the control of pH variations has become as familiar and commonplace in continuous processing as the control of flow, pressure, and temperature. Virtually every industry, ranging from the manufacture of fertilizers and explosives to soap, paint and pineapple juice, has discovered the importance of pH measurement and control. A review of pH theory and its practical applications in industrial measurement and control are contained in Bulletin 430-1, issued by The Foxboro Company. The 16-page bulletin is profusely illustrated.

Circle letter (AN) on reply card.

(AO) ROD PACKINGS

A new 8-page bulletin outlining the advantages of Lattice-Braid rod packing has just been issued by The Garlock Packing Company. The bulletin contains sectional drawings showing the unique structure of Lattice-Braid packings, illustrations of different types, tables showing general service recommendations and specifications, and reports from users.

Circle letter (AO) on reply card.

(AP) ROTARY HOSE

Chiksan Company has just issued an illustrated bulletin describing its new all-steel rotary hose designed specifically for portable rigs. The complete assembly consists of a standpipe swivel-arm — designated a hose-saver — which is bracketed securely to the mast leg and extends away from the derrick, an all-steel rotary hose engineered for practical maintenance, and a drilling swivel extension. The new rotary hose bulletin contains photographs, descriptive data, and actual engineering drawings of each unit.

Circle letter (AP) on reply card.

(AQ) CARBON STEEL TUBING

Technical information of value to engineers and designers associated with the fabrication of equipment operating at elevated temperatures and pressures is presented in a new data card published by The Babcock and Wilcox Company, tubular products division. Known as TDC 142, the bulletin offers condensed data on mechanical and physical properties, upsetting, swaging, flanging, expanding, bending, and welding of seamless and welded carbon steel tubing.

Circle letter (AQ) on reply card.

Trade Literature

(AR) HYDRAULIC HOIST

A colorful new 8-page catalog titled "You'll Earn *More* with . . . St. Paul Hoists and Bodies" has just been released by St. Paul Hydraulic Hoist. In this catalog St. Paul presents facts on its new line to justify its claim of "22% More Payload per Hoist Dollar" and outlines in detail the many basic improvements incorporated in the completely redesigned line of hoist and bodies recently released.

Circle letter (AR) on reply card.

(AS) SEAMLESS TUBING

A new bulletin designed to help the tubing user in determining whether he should use hot finished, cold drawn, or "roto-rocked" seamless mechanical tubing as the basis for his product has been issued by the Tubular Products Division of The Babcock and Wilcox Company. Known as TB-340, the bulletin outlines the differences in methods of production, surface finish, tolerances and costs of tubing finished by the three processes.

Circle letter (AS) on reply card.

(AT) EMERGENCY POWER

How a super service truck station continued to serve its many customers when a crippling storm cut power for six hours; how thousands of loaves of bread are prevented from spoiling if power for oven conveyors is cut off; how civil defense communications stations are protected—these and many other examples of how emergency standby power serves business and community life are contained in a 24-page, two-color magazine, *Power Points*, published by D. W. Onan and Sons, Inc. Illustrated with over 60 striking photos, the magazine gives a report of standby installations in hospitals, schools, farms, dairies, hatcheries, country estates, and government agencies, etc.

Circle letter (AT) on reply card.

(AU) REFRIGERATION DRIVES

E-M Synchronizer No. 36 quarterly publication of the Electric Machinery Manufacturing Company deals with the application of A-C motors to centrifugal refrigeration compressors. In a lead article on this subject, G. L. Oscarson, chief application engineer of Electric Machinery discusses refrigerant characteristics, compressor capacity control, motor characteristics, and motor control. Other articles include "The Line Diagram" and "How to Select Control for Wound-rotor Motors" in addition to two highly illustrated feature articles of general interest.

Circle letter (AU) on reply card.

(AV) COOLING TOWERS

A new illustrated, 36 page catalog on cooling towers has been issued by Foster Wheeler Corporation. The booklet contains details of construction, charts, suggestions on recirculation, and surroundings. It also includes "Inquiry Data Sheet" for planning one's requirements.

Circle letter (AV) on reply card.

(AW) PUMPS

Ingersoll-Rand Company announces development of the Class SFLA pumps for handling light refinery liquids at temperatures to 250 F. Using the same hydraulic design as the company's existing single-stage, vertically split process pump line, these units are distinctive since they are the first to be designed around the use of a Cameron Mechanical Shaft Seal as standard equipment. Catalog 7094-A describes the pumps.

Circle letter (AW) on reply card.

(AX) GAS ENGINES

Four-cycle gas engines of 5, 6, 7 and 8 cylinders, manufactured by Worthington Corporation, are described in an 8-page Bulletin S-550-B18A.

The bulletin includes pictures and specifications of the totally enclosed gas engines which are designated by Worthington as their Type DDG. They feature a 15-in. bore by 17½-in. stroke in 50 and 60 cycle operation.

Circle letter (AX) on reply card.

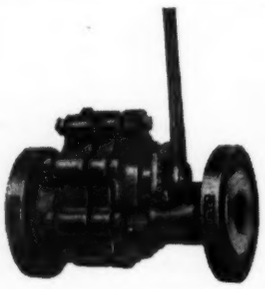
(AY) MOTOR DRIVES

Allspeed Motor Drives of from 1/3 to 7½ hp are described in a 16-page bulletin published by Worthington Corporation. Described and pictured are both upright and horizontal drives of either closed or skeleton types. Sixteen pictures graphically portray the ease of belt change.

Circle letter (AY) on reply card.

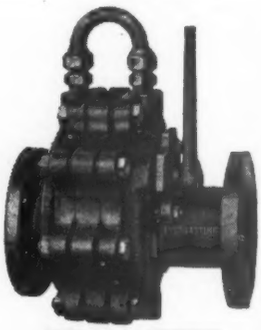
FIRE PROTECTION

Closing type for inflammable liquid emergency shut-off, or opening type for deluge or drainage, assuring immediate and positive action with weighted pendulum stop.



GENERAL SERVICE

Wherever frequent use and quick operation is required for any liquid or gas at pressures up to 300 psi. These valves have outside stuffing box and gland.



STEAM JACKETED

Assures continued free flow of any material which congeals at ordinary temperatures.

BOILER BLOW-OFF

Quick-opening, also handwheel operated Angle and "Y" types and combination units meeting ASME Code requirements for pressures up to 600 psi.

"Everlasting" Protection

Quick-Action . . . opened or closed with less than a quarter turn of the operating lever.

Straight-Through Flow . . . the disc cannot become loose and accidentally check the flow.

Drop-Tight Seal . . . constant contact of disc and seat at all times prevents dirt or scale from getting between.

Self Regrinding . . . the disc rotates on the seat with each operation, thus regrinding the sealing surfaces.

No wedge action . . . all parts move between parallel faces.

Write for bulletin describing EVERLASTING VALVES in detail.

EVERLASTING VALVE COMPANY

49 Fisk Street, Jersey City 5, N. J.

Everlasting Valves

Trade-Mark "EVERLASTING" REG. U. S. PAT. OFF.

(AZ) AMPLIFIER

A bulletin just issued describes Consoldiated Engineering Corporation's Type 1-118 carrier amplifier, which is designed primarily for the smaller engineering and development laboratory not having a full-time staff devoted exclusively to testing. All components of the 4-channel system are contained in one compact cabinet. The great number of commercially available pickups satisfactory for use with the 1-118, permit measurement of physical phenomena such as temperature, displacement, torque, pressure, etc.

Circle letter (AZ) on reply card.

(BA) PERIODIC CHART

Fisher Scientific Company recently announced its new notebook-size simplified periodic chart. For individual student use, the 8½- by 11-in. chart permits the student, at his seat in a large lecture to follow a discussion of the periodic arrangement of the elements from his own notebook chart. Metals on the new chart are separated from non-metals; group "A" elements are separated from "B" elements; Lanthanum and Actinium series, including 97 and 98, are distinctly separated from the other elements.

Circle letter (BA) on reply card.

(BB) TORQUE CONVERTER

Ideco has released a bulletin describing its new Hydrair 35 series torque converter drilling rig. This new rig is designed for 350 input horsepower, and is available in single and dual engine arrangements. A special model in this series, described as the Hydrair 35-DD, is equipped with an extra large sandline drum that increases its servicing rating to a depth of 16,400 ft. The new 35 series features an optional hydromatic brake arrangement as well as extra large brakes on the main drum. Other features are a jaw clutch to disengage the catshaft while drilling, oil pressure lubrication of all chain drives and bearings, with chains enclosed in oil-tight guards, etc.

Circle letter (BB) on reply card.

(BC) GEAR DRIVES

Western Gear Works has announced a new catalog, which describes gear drives for every type of pumping service. It portrays the standard high-speed units, special high-speed units, and standard speed-reducers. Western Gear offers complete service to the petroleum industry, including design, production, testing, and application of all types of gear drives.

Circle letter (BC) on reply card.

(BD) COMPRESSORS

Worthington Corporation has published a new bulletin, C-1100-B38, on ammonia refrigeration compressors. Specifications, pictures, and descriptions are included on self-contained refrigeration units for ammonia, single-acting booster compressors, 4- and 6-cylinder high-speed ammonia compressors, gas engine refrigeration compressors, etc.

Circle letter (BD) on reply card.

(BE) METAL GRATING

The new 4-page catalog entitled "Klemp 4 Grates Serving the Nation's Major Oil Companies" describes the construction of Klemp's new "Klemp-Krest" welded grating, which incorporates a crested cross bar between the bearing bars to provide maximum non-slip characteristics. The catalog also gives complete information on the most effective way of using Klemp Hexteel and Floorsteel reinforcement meshes in fractionating vessels and pipes leading to and from catalyst regenerators.

Circle letter (BE) on reply card.

(BF) WELDED GRATING

The Klemp Metal Grating Corporation announces a new type of open steel welded grating in its new 24-page "Open Steel Grating and Stair Tread Catalog." Fully illustrated and complete with engineering data, charts, and a safe load table for welded and diamond riveted grating, the Klemp Metal has published a new catalog featuring their new "Klemp-Krest" grating. The new "Klemp-Krest" welded grating features round steel cross bars so formed as to provide a peak, or crest, on the top side of the bar.

Circle letter (BF) on reply card.

(BG) COMPANY HISTORY

Refinery Engineering Company has announced a new 24-page, 2-color brochure giving in picture and story the history of the company. Pictures of the management are included, introducing the staff, executive and departmental offices, a description of the design, process, purchasing and construction departments. The last few pages deal with work done by RECO for other various oil companies.

Circle letter (BG) on reply card.

(BH) TURBOPUMPS

Pacific Pumps, Inc., has published a 4-page bulletin, No. 118, about its steam turbopumps, Types TA and TB. The turbopumps are primarily for continuous boiler feed service in locations where a compact boiler feed unit, capable of instant starting, may be either desirable or necessary. The bulletin illustrates the new pump, and includes a diagrammatical drawing. It features turbine steam chest, case and exhaust manifold cast steel, nozzle rings of chrome alloy steel, and many others.

Circle letter (BH) on reply card.

(BI) EXCAVATORS

Three new specification booklets showing detailed information on the new Gar Wood ¾-yd, Models 75A and 75B excavators and the 75BT truck crane have been announced by Gar Wood Industries. The new booklets illustrate the capacities, ranges and dimensions of the excavators. Additional information on power plants; the right angle drive, the most efficient method of power transmission; travel speeds and controls are contained in this manual to help contractors select the right unit for their job.

Circle letter (BI) on reply card.

(BJ) ELECTROFORMING

The International Nickel Company, Inc., has published a new bulletin on engineering electroforming, containing 6 pages with 7 illustrations and chart. It describes the unique process which places a new tool at the design engineer's disposal and makes possible the simplification of many construction problems. The three commonly electroformed metals, copper, iron, and nickel are compared.

Circle letter (BJ) on reply card.

(BK) COUPLING

De Laval Steam Turbine Company has published a new 4-page bulletin describing the De Laval crown coupling. The 2-color bulletin includes complete data on this flexible coupling, including information on construction, horsepower ratings, speeds, applications, and selection.

Circle letter (BK) on reply card.

(BL) FLUID CONTROL VALVES

Hoke, Inc., has published a series of dimensional data sheets on a new line for fluid control, which it manufactures. These data sheets, put together in a pasteboard folder, give complete valve dimensions and should prove extremely valuable to anyone planning or designing new equipment in the instrumentation or industrial fields. Each data sheet includes a diagram drawing.

Circle letter (BL) on reply card.

(BM) WORM GEAR MOTORS

U. S. Electrical Motors, Inc., has published a new bulletin on the Type GW Syncrogear, a new low-speed right-angle worm-gear motor. The many-colored 6-page bulletin contains illustrations and description of the Syncrogear. Both shafts are journaled in ball bearings for precise location and lowest friction loss. Churning of lubricant is avoided by locating the work above normal oil level. Most ratios of the Type GW Syncrogear are self-locking. The shaft cannot turn when power is off.

Circle letter (BM) on reply card.

(BN) INDUSTRIAL ROPE

Tubbs Cordage Company has published a 28-page, 2-color bulletin on the selection, use, and care of rope. The booklet is fully illustrated, and contains many tables and specifications for the various types rope. Two pages are devoted to care of the rope. Illustrations and descriptions show how to make a short, long, and eye splice, as well as various types of knots.

Circle letter (BN) on reply card.

(BO) INDUSTRIAL ENGINES

Hall-Scott Motor Division of ACF-Brill Motors Company has published a well-illustrated folder on its industrial engines. The bulletin contains a description of the Hall-Scott unit construction, and condensed specifications of the Hall-Scott Model 2268-0 and 2269-0 industrial engines. Also included is a chart showing SAE gasoline engine test code.

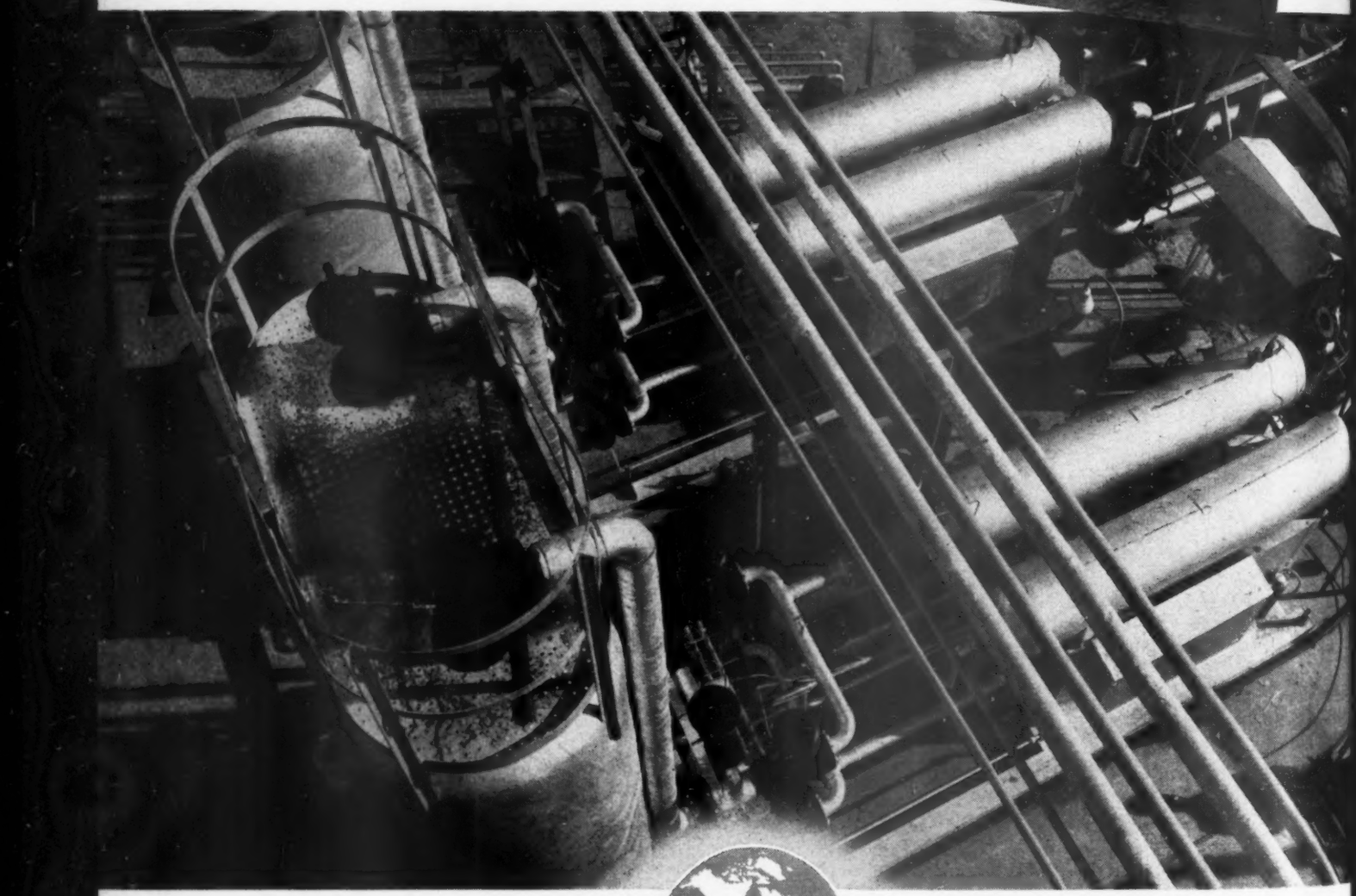
Circle letter (BO) on reply card.

National Dehydration Units

SPECIFIED FOR 10 NEW PLANTS

Nearing completion is the Baxterville plant utilizing two 50 M^2CFD National Dehydration Units. Construction of nine other plants by the world's largest handler of natural gas is in progress. These 10 plants will use 20 Dehydration Units and all will be National.

National Dehydration Units are designed to remove water from natural gas efficiently and economically, in a unit that is compact, portable and automatic..



It's a National

NATIONAL TANK COMPANY

TULSA, OKLAHOMA

8-7-52

REGISTER and VOTE—it's YOUR country